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The Botanical and Entomological Laboratories of the Experiment Station are located in this building.

UNIVERSITY OF VERMONT

AND STATE AGRICULTURAL COLLEGE

126656

THIRTEENTH

ANNUAL REPORT

OF THE

VERMONT AGRICULTURAL

EXPERIMENT STATION

BURLINGTON, VT.

1899-1900

BURLINGTON, VT.:
FREE PRESS ASSOCIATION.
1901.

THE VERMONT

Agricultural Experiment Station

BURLINGTON, VT.

BOARD OF CONTROL

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Hon. E. J. ORMSBEE, Brandon.
Hon. CASSIUS PECK, Burlington.
Hon. G. S. FASSETT, Enosburgh.

OFFICERS OF THE STATION

J. L. HILLS, Director.
G. H. PERKINS, Entomologist.
L. R. JONES, Botanist.
F. A. WAUGH, Horticulturist.
F. A. RICH, Veterinarian.
CASSIUS PECK, Farm Superintendent.
C. H. JONES, Chemist.
B. O. WHITE, Assistant Chemist.
G. W. STRONG, Dairyman.
MARY A. BENSON, Stenographer.
E. H. POWELL, Treasurer.

ANNOUNCEMENT.

The Vermont State Agricultural Experiment Station was established in accordance with an act of the General Assembly, approved November 24 1886, for the purpose of promoting agriculture by scientific investigation and experiment. The station was established in connection with the University of Vermont and State Agricultural College, and for the past twelve years has received the funds appropriated by congress under the provisions of the act commonly known as the "Hatch Act," approved March 2, 1887. The state appropriation expired in 1890. An appropriation "not to exceed $1000 annually" was made by the legislature of 1898 for the purpose of printing the annual report.

The station is prepared to analyze and test fertilizers, cattle foods, seeds, milk, and other agricultural materials and products—exclusive of water—to identify grasses, weeds, blights, etc., and insects, and to give information on various subjects of agricultural science for the use and advantage of the citizens of Vermont.

All chemical analyses, etc., proper to an experiment station, that can be used for the public benefit, are made without charge, so far as time and means permit. The station will undertake no work the results of which are not at its disposal to use or publish if deemed advisable for the public good. The results of each analysis will be promptly communicated to the party sending the sample. Those that are of general interest are published in the annual report or in the bulletins.

It is the wish of the Board of Control to make the station as widely useful as its resources will admit. Every Vermont citizen who is concerned in agriculture, whether farmer, manufacturer or dealer, has the right to apply to the station for any assistance that comes within its province to render, and the station will respond so far as it lies in its power. All communications, relating to agriculture, horticulture, plant or animal diseases, insects, etc., will be fairly considered, and, so far as possible, promptly answered.

The station farm and buildings are on the Williston road, adjoining the university grounds on the east. Electric cars pass within a third of a mile of the station building, at Colchester Avenue and University Place. Both the station and the farm have telephone connections.

Instructions for taking samples of fertilizers, fodders, milk, seeds, etc., will be sent on application. Parties desiring to send samples should first write for these directions. Many samples received are useless, being incorrectly drawn. Parcels by express, to receive attention, should be prepaid and should bear the address of the shipper for purposes of identification.

Copies of the reports and bulletins of the station are sent free of charge to any address upon application.

Address all communications, not to individual officers, but to the

EXPERIMENT STATION, BURLINGTON, VT.

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FINANCIAL REPORT FOR THE FISCAL YEAR ENDING JUNE 30, 1900

Vermont Agricultural Experiment Station, in account with the United States Appropriation, 1899-1900.

DR.

To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1900, as per act of Congress approved March 2, 1887 ....$15,000 00

CR.

	Abstract		
By Salaries	1	$6,588 79	
" Labor	2	2,803 93	
" Publications	3	950 54	
" Postage and stationery	4	518 47	
" Freight and express	5	76 83	
" Heat, light and water	6	328 52	
" Chemical supplies	7	294 03	
" Seeds, plants and sundry supplies	8	121 57	
" Fertilizers	9	106 48	
" Feeding stuffs	10	973 46	
" Library	11	250 22	
" Tools, implements and machinery	12	187 03	
" Furniture and fixtures	13	115 02	
" Scientific apparatus	14	340 67	
" Live stock	15	45 00	
" Traveling expenses	16	574 20	
" Contingent expenses	17	47 60	
" Building and repairs	18	677 64	
			$15,000 00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the Vermont Agricultural Experiment Station for the fiscal year ending June 30, 1900, that we have found the same well kept and classified as above, and that the receipts for the year from the treasurer of the United States are shown to have been $15,000, and the corresponding disbursements $15,000, for all of which proper vouchers are on file and have been by us examined nd found correct.

And we further certify that the expenditures have been solely for the purposes set forth in the act of Congress approved March 2, 1887.

Signed,

{ SEAL. }

MATTHEW H. BUCKHAM,
CASSIUS PECK,
GARDNER S. FASSETT,
} Auditors.

ATTEST,

E. HENRY POWELL,
Custodian.

Receipts and disbursements under sections 4344-4359, Vermont statutes, (fertilizer law); No. 83 of the acts of 1898 (feeding-stuffs law); No. 81 of the acts of 1898 (creamery inspection law); for the fiscal year ending June 30, 1900.

DR.

A. To amount due Sept. 1 1900 from state treasurer (license fees for 1900 for sale of commercial fertilizers)		$1,900.00
B. To funds received from sale of inspection tags for feeding stuffs and forwarded to state treasurer		1,454.38
C. To receipts from applicants for licenses	$ 85.00	
" " " supply houses, creameries and cheese factories for testing Babcock glassware	145.08	
		$ 230.08

CR.

	A	B	C
By Salaries	$516.00	$256.00	$........
" Labor	127.79	30.56	185.27
" Publications	453.07	167.63	....
" Postage and stationery	47.21	84.94	1.11
" Freight and express	11.89	49.06	2.76
" Heat, light and water	60.17	9.36	4.35
" Chemical supplies	198.93	161.48	3.00
" Sundry supplies	....	0.20	....
" Tools, implements and machinery	....	2.25	6.35
" Furniture and fixtures	....	....	....
" Traveling and sampling expenses	481.60	208.29	....
" Contingent expenses	1.20	*368.98	†19.87
" Building and repairs	2.14		
Add amount forwarded to state treasurer against which no expenditures had been incurred prior to July 1, 1900		115.61	
Add balance on hand unexpended			7.37
	$1,900.00	$1,454.38	$ 230.08

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* Inspection tax tags. † Including $12.00 returned to applicants to whom licenses were refused, and $3.41 overdraft on report of 1898-99.

REPORT OF THE DIRECTOR

J. L. Hills

The present report covers the work of the station during the past fiscal year, July 1, 1899, to June 30, 1900. The bulletins and report are both indexed in the latter.

PUBLICATIONS

Nine bulletins and the 12th annual report, aggregating 484 pages of printed matter have been issued during the year in editions of 1500 to 14,000. All except Nos. 72, 73 and 75 have been distributed to the entire station mailing list.[1] Bi-weekly newspaper bulletins have been published throughout the year. Abstracts of the regular bulletins—Nos. 72–80—appear on pages 263–267. A list of publications issued during the year follows :

1899,	September,	No. 72.	Certain potato diseases and their remedies, 32 pages.
	October,	No. 73.	The trees of Vermont, 54 pages.
	December,	No. 74.	The home fruit garden, 12 pages.
1900,	January,		Twelfth annual report, 238 pages.
	January,	No. 75.	Check list of hybrid plums, 12 pages.
	March,	No. 76.	The forest caterpillar, 28 pages.
	April,	No. 77.	Analyses of commercial fertilizers, 24 pages.
	April,	No. 78.	Analyses of commercial feeding stuffs, 24 pages.
	April,	No. 79.	Analyses of commercial fertilizers, 12 pages.
	May,	No. 80.	Analyses of commercial fertilizers, 48 pages.

Bulletins 81 to 86 inclusive, concerning, respectively, the principles and practice of stock feeding, analyses of commercial feeding stuffs, apples of the Fameuse type, analyses of commercial feeding stuffs, potato scab and its remedies, and analyses of commercial fertilizers, have been issued since the close of the fiscal year, but prior to the distribution of this report.

Many of the back bulletins and reports of the station are nearly or quite out of print. Parties having spare copies of any of the publications noted in the following list would confer a favor by returning the same to

---

[1] No. 72 was prepared for the use of the committee of the Association of American Agricultural Colleges and Experiment Stations at the Paris exposition. It was a resumé of previous station publications, and was printed in a small edition only. No. 73 was published more particularly for use in the public schools in connection with nature study. No. 75 was of interest to horticulturists only and was issued in a limited edition. None of these bulletins were sent to the Vermont or out-of-the-state lists but only on special requests.

the station, thus enabling it to comply with requests from libraries and from other stations. Postage will be refunded to the sender on request.

All reports except the Third; Bulletins 1-11, 15, 16, 19, 20, 22, 25, 28-34, 36-40, 42, 45, 50-52, 56, 57, 59-63, 65, 69, 71, 72-75.

RELATION OF THE STATION TO THE PUBLIC

The station seeks to promote the agricultural interests of Vermont in a five-fold manner:

1. By the scientific investigation of matters pertaining to agriculture and the publication of the results of its experimental work in the form of bulletins and reports, and also through the medium of the agricultural, scientific and general press.

2. By sampling, analyzing and reporting the quality of the sundry commercial fertilizers, feeding stuffs, etc. sold in Vermont, and by supervising certain matters related to the conduct of the milk-test system at creameries and cheese factories.

3. By direct correspondence with individuals of all classes, particularly with farmers, and by the personal contact of members of the station staff with the farming community at institutes, fairs, through visitation, etc.

4. By analyzing miscellaneous agricultural materials for residents of the state in accordance with section 263 of the Vermont statutes.

5. By so conducting its farming operations that visible and tangible evidence may be shown of the usefulness of science in agriculture; or, in other words, affording daily object lessons in good modern farming.

1. *Publications.*—The determination and dissemination of new and useful facts of an agricultural bearing is the main function of the station.

It makes an attempt to reach its constituency in many ways, and it is felt that it is yearly becoming more useful. The passage of an act by the legislature of 1898 appropriating not to exceed one thousand dollars annually for printing the station report permits of a larger use of printer's ink by the station than heretofore. Bulletin 81 on stock feeding could not have been issued had it not been for this fund. This sum is a fair offset against expenses incurred in complying with section 263 V. S.

2. *Inspection work.*—This line of work is conducted in accordance with state laws similar to those in other states and serves in some degree to put the traffic and practice on a higher plane.

3. *Correspondence, etc.*—This class of work continues to make serious inroads upon the time of the director and of other members of the staff. It is, however, a legitimate line of station service, helpful to the farmer, and is gladly undertaken. The personal contact of station workers and farmers is to be encouraged. In few ways can the results of station endeav-

ors be brought home more directly to the farmer, or his needs and perplexities be more clearly realized by the scientist than by their meeting at the institute, in the field or by visitation. The station director has been an active member of the state board of agriculture for fourteen years and station representatives have addressed from 20 to 40 institutes annually.

4. *Miscellaneous analytical work.*—Section 263 of the Vermont statutes requires the station to analyze materials of an agricultural nature without charge to the citizens of Vermont. Parties intending to make use of the station in this way are respectfully referred to the statement in the announcement on page 249. Attention is called to the fact that the station no longer makes water analyses, a class of work now done at the laboratory of the state board of health; also that mineral analyses, the investigation of cases of suspected poisoning, etc., are outside its province.

5. *The station farm.*—The station farm and buildings are open to the inspection of all who may be interested. Visitors are welcome on week days to look over the buildings and stock. The kindly words of approval from thousands of visitors in the past show that the object lesson in good farming, the experiments which appeal to the eye, and the information elicited by direct questioning of those in charge alike prove helpful.

RELATION OF THE STATION TO THE STATE

The income of the station is derived from several sources, including the congressional grant, state printing appropriation, license fees from commercial fertilizer companies, inspection taxes on certain feeding stuffs, creamery glassware and operators' fees, and sales of farm produce. The financial reports showing the expenditure of several of these funds are printed on pages 252-253. Statements concerning the workings of sundry state laws may be found in bulletins 77-80. It is to be noted that the state laws require the station to do a class of work, which, while unquestionably of much value to the farming interests, is held to be outside the province of the national enactment.

WORK OF THE YEAR

Concise statements of the main results of station endeavor during the past year published in this report (not in bulletins) in the departments of botany, horticulture, chemistry, and dairy husbandry follow.

BOTANY

Potato diseases.—Insects and tip burn hurt the crop more in 1899 than did fungus troubles. Bordeaux mixture proved helpful as usual in combating potato maladies and increased the crop over 40 percent when applied three times, and this notwithstanding the fact that little fungus disease occurred. Half the gain resulted from the first spraying, while the second and third added each about 25 bushels an acre to the yield.—Pages 268-273.

Potato scab.—Given clean seed, and clean soil no scab results; if either be foul, scab follows. No treatment of seed avails if the soil or manure contains the scab fungus. The abandonment of the field for potato growing alone is effectual. Corrosive sublimate, formalin, both liquid and gaseous, prolonged exposure to sunlight, etc., proved helpful as means of killing the scab fungus.—Pages 273-281.

Killing weeds by chemicals.—The so-called "kale" (charlock and wild turnip) was combated in oats by spraying with copper sulphate (blue vitriol) solution. The charlock was practically all killed out, but the wild turnip proved more resistant, not over one-half being killed. The oats were uninjured. Spraying in the middle of June with a weak solution, one pound to six gallons, proved more satisfactory than did spraying ten days later with a stronger solution. The expense was slight.—Pages 282-286.

Impurities in grass and clover seed.—Many farmers pay high prices for pigweed, purslane, kale, plantain, and the like, buying them for grass and clover. Clean timothy is purchasable. It is largely a matter of price. Not so with clover, however, since high price does not insure pure seed. Such seed ought to receive critical examination and should be bought discriminatingly of reliable and careful dealers only.—Pages 287-299.

Soft rot of carrots and other vegetables.—A rot of this character reported from Hardwick and elsewhere was found to be due to a hitherto undescribed bacterium. This has been carefully studied and described. The remedial measures in cases of this disease are rotation of crops, the avoidance of the use of contaminated manures, the exposure of harvested roots to sunlight and low storage temperatures.—Pages 299-332.

HORTICULTURE

Propagation of plums.—A preliminary report is made of experiments in the propagation of plums. The subject is very complicated from the fact that different sorts of plums differ greatly in their habits and requirements, and from the added fact that many widely diverse stocks are used in propagation. The selection of a suitable stock for a given variety and for a given set of conditions, although a matter of prime practical importance, has never hitherto been made the subject of systematic experiment. In the trials herein reported, Americana stocks gave unexpectedly good results, yielding the largest average of trees in each lot, the tallest trees, and considerably the largest number of merchantable trees. Marianna, a stock in common use, gave poorer results than had been expected. It gave the smallest number of merchantable trees and the smallest number of unions of any stock in the experiment. Wayland and peach stocks were intermediate in most respects.—Pages 335-354.

Plum pollination.—The work on plum pollination carried on at this station for several years has been continued. Extensive studies of pollen were made to determine as far as possible what variations occur, what are their causes, and what their practical result. It appears that pollen varies greatly in quantity though nearly all varieties under nearly all conditions produce enough for purposes of pollination. Quality varies likewise. Some pollen is good and some apparently impotent. Some of the hybrid plums seem to show unusual weakness in pollen bearing. Pollen also varies in germinating power, though usually, in the orchard, germination is strong and sufficient. The causes of these fluctuations in quantity and quality of pollen have kept beyond the reach of experiment thus far, though it seems probable that the germination of pollen is not readily influenced by external conditions. The practical conclusion reached with regard to pollen is that only a few varieties need any attention in this matter, and that, in the management of these doubtful varieties, the plum grower would simply refrain from planting them as pollenizers. Their fruitfulness is not directly affected so long as they are planted with other good pollen-bearing varieties for cross-pollination.

Malformations of blossoms are sometimes interesting, especially in connection with the study of hybridity, but they seldom have any practical result.

Pollen is transported chiefly by honey bees and hardly at all by the wind. This conclusion, announced in an earlier report, is strongly supported by additional experiments.—Pages 355-362.

Pollination of apples.—Apples, like plums, are frequently self-sterile, and require pollen one variety from another in order to make them fruitful. In a large number of experiments made by this station, practically all the varieties tested proved self-sterile, including such common sorts as Baldwin, Fameuse, Esopus, Northern Spy, etc. It is pointed out that, in order to secure cross-pollination of two varieties, care must be taken to select such as blossom at the same time. Bees are the chief agents in carrying pollen from one apple tree to another. The wind does not transport apple pollen, at least not to any important extent.—Pages 362-366.

The Myrobalan plums.—Some historical and general notes of the Myrobalan plums are given, and a monograph of the named varieties is added. The Myrobalan plums are extensively used for stocks for other plums, and sometimes for peaches. The few cultivated varieties are of small value in themselves, but appear to be promising for purposes of hybridization. —Pages 366-370.

Plum tree canker.—An undescribed canker of plum trees is reported and illustrated. This disease is not of fungus nor of bacterial origin, though fungus or bacterial attacks may open up the way to subsequent development of the canker. In fact, the canker most usually follows the brown fruit rot or the plum pockets disease. The treatment suggested is therefore directed to the control of these antecedent maladies.—Pages 370-373.

CHEMISTRY

Composition of potatoes at various stages of growth.—Two years' investigation of the question as to the variation in the composition of potato tubers dug at intervals from early August to frost, points out quite clearly that there are no important measurable differences in the chemical composition of the potato tuber brought about by advancing maturity. Hence the loss from the early death of the vines by disease and the gain from their prolonged life resulting from spraying is one of quantity only.—Pages 374-382.

Composition of the artichoke plant and tuber at various stages of growth.—A crop of improved French white artichokes, grown in the season of 1898, and sampled at ten day intervals from early August until frost, increased in dry matter percentage of the stalks, but not of the tubers. Although much care was exercised in sampling and analysis several anomalies appear in the results. No decided modifications in the composition of the tubers appear to result from increasing maturity.—Pages 382-386.

DAIRY HUSBANDRY

Feeding trials with cows.—The problems studied were :

(*a*) The effect on the quantity and quality of milk and on the economy of production, of low, medium and heavy grain feeding ; also the limit of profit in the addition of grain to a ration.

(*b*) The effect on the quantity and quality of milk of the addition to a ration, already fairly well adapted to milk making, of a considerable proportion of a single nutrient, either protein, carbohydrates or fat.

(*c*) The feeding value of buckwheat middlings compared with a mixture of corn, bran, cottonseed and linseed meals, considerably less rich in protein and fat than the buckwheat byproduct.

(*d*) The feeding value of buckwheat middlings compared with a half and half corn and bran mixture.

(*e*) The variation in production following the use of two rations affording food supplies essentially equal in total amount but unequal in the amounts of the various nutrients, i. e. medium and wide rations.

(*f*) The variation in production following the use of dissimilar rations each containing essentially the same amounts of the various nutrients.

(*g*) The effect on production of grooming cows.

(*h*) The effect on production of allowing cows to drink at will instead of at stated intervals.

(*i*) The effect on production of warming water for cows.

The essential results may be stated as follows :

(*a*) *How much grain may be fed with profit to dairy cows?*—Four, eight and twelve pounds of three different grain rations were fed at different times with hay and silage to 11 cows, each animal being kept throughout the experiment upon the same grain ration, so far as character is concerned, but a different one as regards its amount. The outcome was essentially as follows :

Quantity.—The more grain, the more milk, total solids and fat.

Quality.—Only slight changes were observed as a result of variation in amounts of grain fed. Such alterations as occurred were in the general direction of better milk on medium than on either low or high feeding.

Economy of production.—A pound of dry matter produced more on the low than on either the medium or high grain feeding. There was but little difference in this respect between the medium and the high ration.

Live weight.—Increased feeding usually affected the milk flow only in the first few months of lactation, but from the fourth month on there seemed to be a greater tendency to affect live weight than to alter the milk flow.

Financial outcome.—In these trials an increase of grain from four pounds to eight or to twelve pounds seldom yielded enough more butter to pay the cost of the extra grain. In practically every case, however, there was enough more skimmilk and enough better manure made to more than offset the extra expense for grain. When the byproducts are considered the profit is each time in favor of the 8 pound ration as compared with the 4 pound and generally in favor of the 12 pound as compared with the 8 pound ration. As to the advisability of the 12 pound or heavy ration it may be questioned whether so large a proportion of concentrates is desirable, viewed from the standpoint of the health of the animal. The wisdom of such feeding will depend upon a multitude of considerations.

(*b*) *The addition to the ration of excessive amounts of single nutrients.*—*Protein.*—The addition of about one-fifth more digestible protein to a ration already containing amounts of this nutrient greater than standard requirements was practically without effect as a milk stimulant.

Carbohydrates.—The addition of about one-fifth more digestible carbohydrates to a ration containing amounts of these nutrients equal to or in excess of standard requirements had little or no effect upon either the quantity or quality of the milk flow.

Fat.—The addition of a solid fat to a ration already containing digestible ether extract in excess of standard requirements increased its digestible fat content about one-half. It had a slight effect upon the quantity and a pronounced effect upon the quality of the milk flow. The total solid percentage was increased 2 percent (0.24 percent) and the fat 7 percent (0.36 percent). The increase appears to have been permanent.

(*c-d*) *The feeding value of buckwheat middlings.—Quantity of milk.*—Buckwheat middlings and cottonseed, linseed, corn and bran mixture (No. 1 of these trials) were of about equal value as producers of milk, total solids and fat. Buckwheat middlings made from 8 to 11 percent more milk, solids and fat than did the mixture of half corn and half bran.

Quality of milk.—Whenever buckwheat middlings were fed the quality of the milk was improved nearly 0.20 percent. This disproportionate increase in the fat content of the milk was observed in last year's trials, and is plainly seen this year. It seems quite clear, therefore, that buckwheat middlings may be expected to increase slightly the fat percentage of milk.

Financial considerations.—Buckwheat middlings made cheaper milk and cheaper butter than did the cottonseed-linseed (No. 1) ration. It made a decidedly cheaper milk and butter than did the corn and bran ration.

(*e*) *The feeding values of medium and wide rations.*—The medium ration produced 6 percent more milk, total solids and fat than did the wide ration. The quality of the milk remained unchanged.

(*f*) *The relative feeding values of rations of equal balance.*—But 2 percent more product was yielded to the unit of dry matter on one ration than was obtained from the other. The quality of milk remained unchanged.

Financial considerations.—The cottonseed, linseed, corn and bran (No. 1) ration proved superior to the Quaker dairy feed ration, in that it made enough more butter and skimmilk and enough better manure to more than offset its increased cost.

The corn and bran and Quaker dairy feed made equal quantities of milk and of butter.

(*g*) *The grooming of cows.*—In this year's trials there was 4 percent less milk yielded when the cows were groomed than was given when they were left uncarded. The quality of the milk remained unaltered. The grooming of cows should tend to better the keeping quality of the milk and the grade of butter, but it will not add to the milk flow or to its fat content.

(*h*) *Watering at will and at intervals.*—No more and no better milk was made when the cows drank at will than when they drank twice daily.

(*i*) *Warming water for cows.*—Warming water from 45° to 70° F. did not avail to improve either the quantity or the quality of the milk yield with cows stabled in relatively warm barns.—Pages 391-443.

The effect of food on the quality of butter.—Buckwheat middlings and palm oil feeding firmed the butter and made it somewhat poorer.—Pages 443-445.

Herd record—The herd made an average of 320 pounds of butter per cow in 1899, and 357 pounds in 1900. Full individual records of consumption and production are given.—Pages 445-460.

PUBLICATIONS ON HAND

The station has issued to the time of distributing this report, including the present number, 13 annual reports and 86 bulletins. Many of these are out of print. The following numbers are in print, and will be sent on request without charge as long as the supply lasts.

Attention is called to the list of reports and bulletins wanted by the station given on page 255 of the present report.

1888, April.	No. 12, Insecticides; Seed Tests; Miscellaneous Analyses	16 pages
November.	No. 13, Methods of Cutting and Planting Potatoes: Fertilizer Analyses	12 pages
	No. 14, Analyses of Fertilizers Licensed for sale in the State of Vermont for the year 1898	16 pages
1889, October.	No. 17, Test of Dairy Cows at Vermont State Fair	18 pages
	Third Annual Report	172 pages
1890, January.	No. 18, Pig Feeding	20 pages
September.	No. 21, A New Milk Test; Testing Milk at Creameries and Cheese Factories; Notes for the Laboratory	32 pages
1891, March.	No. 23, Analyses of Fertilizers Licensed for Sale in the State of Vermont for the year 1891	16 pages
May.	No. 24, Potato Blight and Rot	16 pages
September.	No. 26, Maple Sugar	24 pages
1892, January.	No. 27, Tests of Dairy Apparatus	12 pages
1893, May.	No. 35, Analyses of Fertilizers Licensed for Sale in the State of Vermont for the year 1893	16 pages
1894, May.	No. 41, Analyses of Commercial Fertilizers	16 pages
November.	No. 43, Household Pests	8 pages
December.	No. 44, Spraying Orchard and Potato Fields	28 pages
1895, March.	No. 46, Analyses of Commercial Fertilizers	16 pages
May.	No. 47, Commercial Fertilizers	40 pages
October.	No. 48, Gluten Feeds and Meals	20 pages
December.	No. 49, Potato Blights and Fungicides	24 pages
1896, August.	No. 53, The Pollination of Plums	20 pages
November.	No. 54, Salad Plants and Plant Salads	16 pages
December.	No. 55, Apple Growing in Grand Isle County	16 pages
1897, April.	No. 58, Analyses of Commercial Fertilizers	16 pages
1898, April.	No. 64, Analyses of Commercial Fertilizers	16 pages
September.	No. 66, Club-root and Black Rot of the Cabbage	16 pages
December.	No. 67, Hybrid Plums	30 pages
1899, January,	No. 68, Inspection of Milk Tests and Feeding Stuffs	8 pages
April.	No. 70, Analyses of Commercial Fertilizers	16 pages
1900, March.	No. 76, The Forest Caterpillar	28 pages
April.	No. 77, Analyses of Commercial Fertilizers	24 pages
	No. 78, Analyses of Commercial Feeding Stuffs	24 pages
	No. 79, Analyses of Commercial Fertilizers	12 pages
May.	No. 80, Analyses of Commercial Fertilizers	48 pages
September.	No. 81, Principles and Practice of Stock Feeding	56 pages
	No. 82, Analyses of Commercial Feeding Stuffs	26 pages
December.	No. 83, Apples of the Fameuse Type	16 pages
1901, January.	No. 84, Analyses of Commercial Feeding Stuffs	16 pages
	No. 85, Potato Scab and its Treatment	12 pages
March.	No. 86, Analyses of Commercial Fertilizers	24 pages
	Thirteenth Annual Report, (general edition)	216 pages

Copies of the bulletins abstracted in the following pages will be sent without charge to any address upon application.

ABSTRACTS OF BULLETINS

Bulletin 72—Certain Potato Diseases and Their Remedies

By L. R. Jones

This bulletin was prepared at the request of the committee of the Association of American agricultural colleges and experiment stations for distribution at the Paris Exposition.

It was not sent to the regular mailing list but a copy will be forwarded to anyone making special request for it.

It is a republication of the more important results of the observations and experiments, made at this station during the last nine years, upon potato diseases and their remedies. Most of the original publications are contained in Bulletins 40 and 49 and Reports 6–9, (1892-95).

The contents of the bulletin are:

I. Introduction.—Explaining the economic importance of the potato crop, and of the losses due to various diseases. The average yield in Vermont is 97 bushels to the acre, whereas the average yield from properly sprayed plants at the experiment station for eight years past has been 296 bushels to the acre. The average yield from unsprayed plots at the station during these years has been 173 bushels to the acre.

II. The flea-beetle is the cause of much loss in unsprayed plants. It can best be held in check by bordeaux-paris-green mixture. This same mixture prevents the attacks of other insects also.

III. Two diseases of non-parasitic origin cause considerable loss: arsenical poisoning and tip-burn. The former may be avoided by more care in application of poisons coupled with the addition to them of lime; the latter by attention to culture and by spraying. Sun-scald is another trouble very similar to tip-burn.

IV. Two fungus blights of potato have been distinguished, the early blight and the late blight. Both may be controlled by spraying.

V. Trials of many fungicides have shown that bordeaux mixture is much superior to all others. It is important that this mixture be made properly.

VI. In general two or three sprayings are required with this mixture at varying dates between July 1 and September 1. Economical application requires a good pump with a fine spray nozzle. The barrel pump is best adapted for general spraying, but smaller or more powerful pumps may be desirable in special cases.

Bulletin 73—The Trees of Vermont

BY ANNA M. CLARK

This is an account of the native and spontaneous trees of the state, prepared under the direction of the botanist of the station. It includes an illustration of the leaf or fruit of most species, together with brief statements as to their distribution in the state, value, and distinctive characters. Simple keys are given for use in determining the species in the larger genera.

The bulletin is addressed primarily to the teachers and children as an aid and incentive to nature study in connection with public school work. It will prove, however, of interest and value to many others, including lumbermen and observers of trees. About one hundred kinds of trees are described. Of these seventy are native, nine spontaneous and the others occur only in cultivation.

This bulletin was not sent to the regular mailing list and those who desire it should make special request. At the request of the state superintendent of public instruction, one copy has been deposited as state property in each school house in the state.

Bulletin 74—The Home Fruit Garden

BY F. A. WAUGH

It is pointed out that fruit growing is feasible in all parts of Vermont. More farmers' homes ought to be supplied with home-grown fruit.

I. Directions are given for making a beginning. Choice of location, soil, windbreaks, preparation and drainage are discussed.

II. Hints are given on how to plant trees, where to get the stock, when to set it out, how far apart to plant, varieties to be chosen, etc.

III. Brief directions are given for caring for the fruit garden. Careful cultivation, with cover crops in fall is recommended. Fair supplies of plant food are needed. Pruning may best be done in spring. Winter protection for some plants may be given. Spraying against insects and diseases is advisable wherever the garden is large enough to warrant it.

Bulletin 75—Check List of Hybrid Plums

BY F. A. WAUGH

This bulletin contains merely a list of the varieties of hybrid plums known to this station, giving their correct names, their synonyms, reference to the original publication of the names, references to publications in reports and bulletins of this station, a statement regarding the origin and introduction of each variety so far as known, and the parentage whenever possible.

Bulletin 76—The Forest Caterpillar

BY G. H. PERKINS

The ravages of the forest caterpillar began to attract attention to some extent in this state in 1895, and were extreme in 1898 and 1899. Probably no species of insect has ever attracted greater notice in Vermont, caused more alarm or actually done so much mischief as this. It has been found in nearly all of our towns, but has not been as destructive in the northern part of the state as in the southern.

The eggs are always placed in a band around small tree twigs. The caterpillars emerge early in the spring and are about one-tenth inch long. They begin to spin webs promptly and to feed as soon as leaves appear. They molt four times and finally show sundry colored lines and spots of black, blue and yellow. The caterpillars cluster when resting. They eat the leaves of maples, apple, oak, poplar and many other trees. They form cocoons in sheltered spots in June, the moth emerges in July and begins to form egg clusters promptly.

The damage done to the maple groves of the state is incalculable. Apple orchards have also suffered severely.

The insects are combated by both natural and artificial means. Sundry birds and predatory insects attack them. A large share of the cocoons in 1899 were punctured by a parasitic fly. A fungus disease sometimes attacks them. Man may battle against the enemy by destroying the egg clusters, by spraying, by crushing or burning the caterpillars when clustered, by banding the trees, thus preventing them from climbing the trunks, by destroying the cocoons and by catching the moths.

Bulletin 78—Analyses of Commercial Feeding Stuffs

BY J. L. HILLS, C. H. JONES and B. O. WHITE

Two hundred and sixty-five samples of feeding stuffs, collected in the fall of 1899, have been analyzed.

No cases of adulteration were found among the cottonseed, linseed or gluten products, although certain brands do not grade as high as others and are open to improvement. There seem decided tendencies towards greater uniformity of quality with several brands.

Many brands of oat feeds, dairy feeds, corn and oat feeds, provenders and the like were found to contain a large quantity of oat hulls, more than they should carry were the goods made from "pure grains ground together." Such feeds are of inferior quality and their purchase is of very doubtful advisability.

The more highly concentrated feeds cost more, but, for the purpose for which such materials are generally bought—to furnish protein,—are much less expensive than low grade goods.

The attention of both dealer and consumer is called to the "free analysis" offered on page 186 of the bulletin.

Bulletins Nos. 77, 79 and 80—Analyses of Commercial Fertilizers

BY J. L. HILLS, C. H. JONES AND B. O. WHITE

I. The trade values for 1900 per pound of the ingredients as found in mixed goods are as follows: Ammoniacal, nitrate and organic nitrogens, 17, 13½ and 15½ cents respectively; soluble, reverted and insoluble phosphoric acids, 4½, 4 and 2 cents respectively; potash, as sulphate, 5 cents, as muriate, 4½ cents. It should be particularly noted, however, that these trade values do not represent the proper selling prices of mixed goods at the point of consumption, but are the retail trade values or cash costs of amounts of nitrogen, phosphoric acid and potash, equal to those contained in a ton of the the brand in question, in standard unmixed raw materials of good quality, at the seaboard. They do not include freight, cost of manufacture, storage, commissions, etc. They stand in no necessary relation to the profits derived from the use of the goods, but have a purely commercial significance.

II. The station has analyzed 132 brands, the output of nineteen companies, all drawn from dealers' stocks, all this year's goods.

1. Quantity of plant food furnished.—Six-sevenths of the brands were up to or above guaranty, one-seventh fell short somewhat, and one-twentieth failed to furnish a commercial equivalent of their guaranties.

2. Quality of plant food furnished.—While as a rule the quality of the crude stock used was good, there were some cases which seem open to criticism. Two-fifths of the brands carried no water-soluble nitrogen. There appears to have been somewhat inferior forms of nitrogen used in certain cases, notably in some low grade goods and by two companies, whose goods have been on this account open to some suspicion for three years. The phosphoric acid was in some cases quite largely in the insoluble or reverted forms, indicating apparently either much undissolved bone, imperfect manufacture, old goods, or more or less use of (agriculturally) inferior forms of this ingredient. Sulphate of potash is claimed to be present in three-fourths of the brands, but was actually found in but one-seventh.

3. Selling prices and valuations.—The average selling price approximated $28.73 and the average valuation, $18.08. Two dollars in every five paid for fertilizers met the costs of manufacture and sale. An amount of plant food which cost a dollar might have been bought at retail for cash at the seaboard for 58 cents in average low priced goods, for 63 cents in average medium grade brands, and for 68 cents in average high priced goods. In nearly one-fourth of the entire number of brands, a dollar was charged for amounts of plant food which might have been bought at retail in the larger markets for 55 cents or less. "Cheap fertilizers" are usually the most expensive.

V. *The average composition* of the brands sold is perhaps very slightly higher than last year. Selling prices have remained unchanged notwithstanding an advance in the price of crude stock. Plant foot is as cheap as it ever was ; yet buying mixed goods on time is still a more costly method of getting plant food than is home-mixing or buying on special order.

VI. *The comparison of analyses of 133 brands for five years* shows in some cases essential evenness and in others considerable variation in composition. The tables showing composition for five years should prove helpful to the early buyer of mixed goods.

REPORT OF THE BOTANIST

L. R. JONES

The investigations of this year have been conducted along the same lines as in previous years. The greater part of the time has been given to studies of plant diseases and their remedies. Investigations and observations have been made in addition upon weeds and herbicides or chemical weed-killers, impurities of grass and clover seeds, and various agricultural grasses and clovers. The experimental studies of maple sap pressure and flow have also been continued. In several of these subjects the work is still in progress and publication at this time is undesirable.

There was no regularly appointed assistant botanist during this year. Valuable aid was received, however, from two persons. Mr. Clifton D. Howe, a graduate student in botany, has attended to most of the details of the seed examinations and the report upon the impurities of grass and clover seed was prepared by him. Mr. A. W. Edson has had immediate charge of most of the experimental work in the field since July 1, 1899. Upon July 1, 1900, Mr. Edson was appointed assistant botanist for the ensuing year and in this capacity he has aided materially in preparing the present report for the press.

The subjects to be discussed are as follows:

Potato diseases and their remedies.
  I. Potato diseases as they occurred in 1899.
  II. Results from spraying potatoes in 1899.
    1. Relative values of various compounds.
    2. Relative gains from spraying at different dates.
  III. Experiments in the prevention of potato scab.
Leaf-scorching of trees by the wind.
Killing weeds with chemicals.
  I. Sulphuric acid compared with salt for the orange hawkweed.
  II. Killing kale with copper sulphate.
Impurities of grass and clover seeds.
A bacterial soft rot of carrots and other vegetables.

POTATO DISEASES AND THEIR REMEDIES

1. POTATO DISEASES AS THEY OCCURRED IN 1899

The season of 1899 was a dry one, but on the whole fairly favorable to the potato crop at Burlington. The yields were reduced by dry weather, but as stated below, there was less disease than usual. The unsprayed plants of the vigorous later varieties, such as Rural New Yorker and White Star, lived well into September. By September 25 most of them were dead owing, however, to insect and physiological troubles rather than to fungus blights. The flea-beetle was, as in former years, a most serious pest, its destructive work on the plants being evident from July 25 to the close of the summer. Tip-burn appeared in the experimental plots about August 15, being relatively much worse on sandy soil than on heavier land. Spraying with bordeaux mixture was decidedly beneficial in warding off these troubles and thereby prolonging the life of the plant as is shown in the succeeding account. Plants protected by this spraying had a full month added to their effective development.

II. RESULTS FROM SPRAYING POTATOES IN 1899

1. RELATIVE VALUES OF VARIOUS COMPOUNDS

Experiments were planned in continuation of those of former years to determine the relative values of various fungicides and insecticides upon potatoes. In considering these results it should be borne in mind that there was no fungus blight on any of the sprayed or unsprayed plants. Had there been, the results might have been materially altered.

These trials included the following compounds:

Standard bordeaux-paris-green mixture.—One and one-half pounds copper sulphate, 1 pound lime, 2 ounces paris green, 10 gallons water. This is the mixture which, after ten years of experience, we have found best suited for general spraying. The method of preparing the mixture has been to make two stock solutions, one containing the copper sulphate dissolved in water at the rate of 1 pound of sulphate to 1 gallon of water; the other containing 1 pound of lime and 2 ounces of paris green, to each gallon of water. Much care is taken to slake the lime properly and thoroughly. These stock solutions are made at the beginning of the season and when it is desired to make up the bordeaux, the desired amount (four gallons) of the lime-paris-green water is put into the barrel of the spray pump, which holds about 45 gallons. While the barrel is being filled with water, the sulphate solution (6 gallons) is gradually added with frequent agitation of the whole. Everything that goes into the pump is passed through a fine brass strainer. In this way a uniform mixture of a bright blue color is secured, free from matter which might interfere with the operation of the pump or nozzles.

Bug death.—Light application, 2½ pounds to the acre.

Bug death.—Heavier application, 5 pounds to the acre, (on one plot it was applied at the rate of 60 pounds to the acre). Bug death is a fine powder and was applied by means of a "Perfection" shaker as directed by the manufacturers. It was generally put on in the morning before the dew was off the plants.

Laurel green.—Light application, 1 pound to the acre.

Laurel green.—Heavier application, 2 pounds to the acre.

A Leggett powder gun was used in putting on this preparation. It was generally applied in the morning while the dew was on the plants.

Plaster and paris green.—One pound of paris green in 80 pounds of plaster and applied very heavily, at the rate of about 180 pounds an acre.

Two similar plots were planted on May 18 for experimental spraying. The soil was a fairly uniform heavy clay loam. Plot I was planted with White Star, plot II with Delaware. During the first part of the summer all the plants were poisoned alike with paris green in water as often as necessary, to protect them from the Colorado potato beetle. A similar application of paris green was made upon the check rows during the latter part of the summer at each time that the remainder of the rows were sprayed experimentally. The experimental applications were made on July 26, August 17 and September 8.

The method of treatment on the two plots I and II was the same, the rows on each being sprayed as follows :

Rows 1 and 2. Check ; paris green in water.
Rows 3 and 4. Bug death ; 2 to 3 pounds to the acre.
Rows 5 and 6. Laurel green ; 2 pounds to the acre.
Rows 7 and 8. Bordeaux-paris-green mixture.
Rows 9 and 10. Paris green; 3 pounds, gypsum 180 pounds to the acre.
Rows 11 and 12. Check ; Paris green in water.
Rows 13 and 14. Bug death ; 5 pounds to the acre.
Rows 15 and 16. Laurel green ; 1 pound to the acre.
Rows 17 and 18. Check ; Paris green in water.

From time to time observations were made upon the condition of the plants in different rows.

At the time of the first application and for nearly two weeks thereafter no difference could be distinguished in the condition of the several plots. All seemed to thrive alike. But by the time of the second application, August 17, marked differences showed themselves and from that time on these differences increased, as is indicated in the following paragraphs.

Bordeaux-paris-green mixture.—In all cases, the plants in the bordeaux rows were larger and more flourishing, with leaves larger and of a darker green color. Little evidence of work of either the Colorado beetles or the flea-beetles could be found upon them. Compared with the other rows, there was very little tip burn and new shoots continued to form upon these plants until the close of the season. It was only after the first frosts that the plants began to die and when the potatoes were dug (October 20) the stems were green with some green leaves.

Check rows.—These were visibly inferior to the bordeaux rows on August 17. There was considerable tip burn, more in some checks than others, and the work of the flea beetles was very noticeable. A week later, August 24, the check rows were plainly distinguishable from the others, having a brown color quite different from the dark green of the bordeaux rows. September 28 most of the plants were dead.

Paris-green-gypsum rows.—These appeared rather better than the check rows throughout the latter part of the season. There was somewhat less flea-beetle work upon them, but the amount of tip burn was very nearly the same.

Laurel green.—These rows were better than the check rows and appeared about the same as the paris-green-gypsum rows. Laurel-green was effective in destroying the Colorado potato beetle and it lessened the injury from the flea-beetle although it did not entirely prevent it. There was, however, serious burning of the foliage (arsenical poisoning) where this powder was used in the heavier amounts. The manufacturers promise to remedy this. Until this is done, it is hardly safe for use on potatoes.

Bug death.—The rows where this was used were kept in better condition than were any of the others in the field except the bordeaux rows. Bug death seemed to protect the plants against both the Colorado and the flea beetles. In one corner of the main potato field, trial was made of very heavy applications of Bug death, viz: 60 pounds an acre on each of the three dates of spraying. The results were that on these rows the vines were preserved in just as healthy condition as were the adjoining rows which received the standard bordeaux-paris-green mixture. The amount of Bug death here used, a total of 180 pounds to an acre, is of course prohibited in field practice by its cost, but the results serve to show that Bug death has real virtues and also, that even in excessive amount it does not hurt the foliage.

The plots were dug October 20. The following table gives the results expressed in terms of bushels to the acre:

YIELDS FROM PLOTS SPRAYED EXPERIMENTALLY

Nature of application	Yields in bushels per acre		Average of the two plots
	Plot I White Star	Plot II Rural N. Y.	
Bordeaux-paris-green mixture	227	237	232
Check. Paris-green in water	166	168	167
Gypsum-paris-green mixture	179	189	184
Laurel green, 1 pound per acre	141	197	169
" " , 2 " " "	151	181	166
Bug death , 3 " " "	217	190	203
" " , 5 " " "	187	201	194

These results are especially significant when it is remembered that there was no fungus blight whatever upon any of the potatoes. Bordeaux mixture is used primarily as a fungicide but from the above returns, coupled with similar evidence of former years, it is clear that it is also a most valuable remedy against insect attacks. Moreover it stimulates more vigorous leaf development. It is regretted that we were again, as in 1898, left without a basis for judging of the relative merits of the various substances as fungicides. Upon this point there is no reasonable ground for doubt, however. Bordeaux mixture stands without an equal in this respect. We are therefore again led to state, as in every former trial, that the standard bordeaux paris-green mixture is far superior to any other substance as yet tested by us, for practical use as a combined insecticide and fungicide for potatoes. The amount of gain from the use of this mixture on the smaller scale on our experimental plots, was almost exactly duplicated upon the main potato field of the farm. This was a moist sandy loam, and the plants were sprayed three times. Some unsprayed rows were left in one corner of the field for comparison. The result was a yield of 150 bushels an acre from the unsprayed rows and of 223 bushels from the adjoining sprayed field.

Adding the average of these figures obtained in 1899 to those obtained during the previous eight seasons of experimental use of bordeaux mixture, we have the gratifying results shown in the following table. In the face of these figures, showing as they do an average gain of 117 bushels an acre in return for two or three applications of bordeaux mixture, it seems beyond question that the spraying of later potatoes should be generally practiced in Vermont.

GAINS FROM USE OF BORDEAUX MIXTURE ON LATE POTATOES

Variety	Planted	Sprayed	Yield per acre		Gain per acre
			where sprayed	where not sprayed	
White star....	May —, 1891	August 26, September 8	313 bu.	248 bu.	65 bu
" "	May 20, 1892	July 30, August 13, 25	291 "	99 "	192 "
" "	May 20, 1893	August 1, 16, 29	338 "	114 "	224 "
" "	Apr. 26, 1894	June 16, July 17, August 30	323 "	251 "	72 "
" "	May 20, 1895	July 25, August 13, 31	389 "	219 "	170 "
Polaris....	May 15, 1896	August 7, 21	325 "	257 "	68 "
"	June 1, 1897	July 27, August 17, 28	151 "	80 "	71 "
White star....	May 10, 1898	July 21, August 10	238 "	112 "	126 "
Ave. 3 vars....	May 18, 1899	July 26, August 17, September 8	229 "	161 "	68 "
		Average for past nine years............	288 bu.	171 bu.	117bu.

2. RELATIVE GAINS FROM SPRAYING AT DIFFERENT DATES

The number and dates of applications to secure the best results are matters which vary with the season. To determine the relative importance of each of the three applications of bordeaux-paris-green mixture made in 1899, experiments were planned in which one or two of the applications were omitted. As already stated, the date of the first application was July 26, of the second August 17, and of the third September 8.

The effects of these omissions were judged in two ways, first by the appearance of the foliage upon the various rows, and second by their relative yields.

Careful comparisons of the appearance of the foliage from time to time led to the following conclusions:

1. The first application was the most important of the series. The rows which received this alone were better protected than were those which received both the second and third, but lacked the first.
2. The plants receiving the second application alone, or even the second and third together, looked but little better than the untreated plants.
3. The plants receiving the first and second applications were better protected than those receiving the first and third.
4. The application made at the third date upon plants which received the first and second applications, had a distinct value.

The above conclusions were nearly all borne out by the results obtained upon digging as shown by the following figures which represent the average yields from the various rows:

YIELDS FROM POTATO PLOTS SPRAYED AT DIFFERENT DATES

Applications made	Yields per acre
July 26, August 17, September 8	227 bushels
July 26, August 17	193 "
July 26, September 8	203 "
July 26	185 "
August 17, September 8	150 "
August 17	152 "
Check, not sprayed	134 "

From these results it is evident that the first application was the most important one, and that about one-half of the entire gain was attributable to that; that the second and third were about equal in importance; and that each of them was profitable since it added 25 or more bushels an acre to the crop.

III. EXPERIMENTS IN THE PREVENTION OF POTATO SCAB

The fact has been clearly demonstrated that potato scab is a fungus disease.[1] It has further been shown that the germs of the disease may be carried upon seed potatoes, and also that the fungus may continue to exist in infected soil for at least several years, even if no potatoes are grown there during such period. The practical remedy for the disease, where the soil is free from the fungus, consists, therefore, in the disinfection of the seed potatoes. Where the fungus already exists in the soil, the problem becomes more difficult.

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[1] Thaxter, R. Conn. Exp. Sta., Rpt. 14, p. 81 (1890).

Two chemical solutions have proved satisfactory disinfectants for use on the seed tubers—namely, corrosive sublimate,[1] and formalin.[2] Recently the use of sulphur has been advocated[3] and it has been hoped that the use of this might prevent the development of the disease, even in infected soils.

Comparative trials have been made at this station during previous years, which have led us to believe that both of the above solutions are practically effective as seed disinfectants, but for reasons of convenience and safety, we have been led to recommend the formalin solution. We have heretofore made no trial of sulphur. The present season (1900) we planned a more extensive series of plots than heretofore, aiming to secure evidence as to the value of sulphur upon infected soil, and also of some other methods of disinfection than those heretofore mentioned. For these experiments plots were laid out in three fields, as follows:

Field I. This was a very light sandy soil, selected for this experiment because it had but recently been cleared from timber, with no subsequent cropping, and was, therefore, presumed to be free from the germs of the scab fungus.

Field II. This was a sandy loam which had been manured well in previous years so that it was in excellent tilth for potatoes. No potatoes had been grown on it for at least seven years, and its condition as to soil infection was unknown, although it was feared there might be some germs in the soil.

Field III. This was a clay loam, rather heavy for the best quality of potatoes, but very productive. Potatoes grown upon it the previous season had scabbed badly and it was assumed that the scab fungus had persisted in the soil. It offered, therefore, an opportunity for testing the sulphur method for soil sterilization.

The seed potatoes used were of two varieties, Delaware and Rural New Yorker. Every tuber planted in Field I and Field II was more or less scabby. The Delawares had from one to a dozen well developed scab spots on each tuber, while the Rural New Yorkers were about as scabby as potatoes could be and grow.

In Field III, smooth tubers were used for all except one row. The details regarding each plot are given later.

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[1] Bolley, H. L., N. D. Exp. Sta., Bul. 4 (1891).

[2] Arthur, J. C. Ind. Exp. Sta., Bul. 65 (1897).

[3] Halsted, B. D., N. J. Exp. Sta. Bul. 112 (1895).

Six methods looking to the disinfection of seed or soil, were tried upon one or another of these plots, as follows:

1. *Corrosive sublimate.*—1 ounce in 8 gallons of water; seed potatoes soaked 1½ hours in the solution. Part of the tubers treated two months before planting, and part treated one day previous to planting.

2. *Formalin.*—8 ounces in 15 gallons of water; seed potatoes soaked two hours in the solution. Part of tubers treated two months before planting, and part treated one day previous to planting.

3. *Formaldehyde gas.*—Commercial formalin is a gas, formic aldehyde, dissolved in water. This gas is of course the active agent. Various lamps are on the market for generating this gas for use in disinfecting rooms, etc., and it seemed possible that the use of this gas, instead of the liquid, for disinfecting tubers and seeds, might prove practicable. If so, it has certain manifest advantages over the former method of soaking the seed in disinfecting liquids. We tried this method, using Schering's formalin lamp.[1]

One-half a bushel of exceedingly scabby tubers destined for seed were placed in an air tight box having a capacity of 8 cubic feet. One-half of one of the pastilles or tablets (i. e. ½ gram) was heated in the lamp according to the directions given, and the box was kept closed for six hours thereafter.

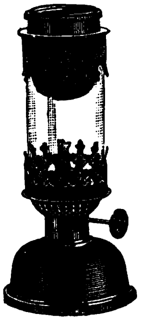

Fig. I. SCHERING FORMALIN LAMP

4. *Sulphur.*—Halsted has found that rolling the seed tubers in sulphur and scattering the sulphur in the drill along with the seed checks the development of scab. This was done in our experiments using the flowers of sulphur at the rate of 300 pounds to the acre in fields I and II and 475 pounds to the acre in field III.

5. *Sulphur fumes.*—The disinfecting value of sulphur fumes for many purposes has long been recognized. The possibility of disinfecting seed-potatoes by sulphur fumes was, so far as we know, first suggested by J. C. Norton,[2] a Kansas potato grower who burned ½ teaspoonful of sulphur in his storage cellar, and believed that his seed potatoes were satisfactorily disinfected as a result. This method is so inexpensive and would prove so convenient for many potato-growers that it is worthy of careful trial by more exact methods than Mr. Norton used.

In our trial one-half bushel of very scabby tubers destined for seed were inclosed in a tight box containing eight cubic feet. One gram of flowers of sulphur was burned in this box which was sealed air-tight immediately after igniting the sulphur and was left thus sealed for twenty-four hours. When opened, the sulphur was found to be practically all consumed and the air was heavily laden with the sulphurous gas.

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[1] This lamp was obtained from Schering & Glatz, 55 Maiden Lane, New York City. It consists essentially of an alcohol lamp and a reservoir to receive the tablets which generate the formalin gas when heated. The outfit is very simple and is accompanied by full directions and a package of 40 of the 1 gram tablets or pastilles. Price, $1.75. See Fig. I.

[2] Norton, J. C. A New Way of Preventing Scab, Rural New Yorker, Oct. 21, 1899. Mr. Norton states that his cellar was 32x20 feet inside, height not given, and contained 400 bushels of potatoes.

6. *Insolation.*—Sunlight has well-known germicidal action. The possibility of destroying the germs of the scab upon the surface of seed potatoes by exposure to sunlight, was brought to our attention by Mr. D. C. Hicks of Clarendon, Vt., who says that he has been in the habit of thus exposing some of his seed potatoes in order to hasten growth, and that he has observed for several years the comparative freedom from scab of the crop from tubers so treated. For the purposes of our experiment scabby potatoes designed for seed for Field I were exposed upon a sunny shelf in the green-house for one month before planting (March 28 to April 24). They lay in a single layer and were turned over four times, about once a week, that all parts of the tuber might receive the direct light. They were benefited by this treatment as shown by the fact that these rows in Field I were up a week ahead of any of the others. Another lot designed for use in Field II, lay from March 28 till May 23. The sprouts on these developed too far and were thereby so weakened that they did not grow well after planting.

DETAILED ACCOUNT OF THE PLOTS AND RESULTS

Field I.—As already explained this was virgin sandy soil. It was considered to be entirely free from the scab germs and the results indicate that this supposition was correct. There were twenty-one rows each six rods long. The potatoes were planted April 24 and dug August 29. The rows were three and a half feet apart. Scabbed seed of the two varieties was used and in each case two adjacent rows were planted to seed which had been given the same preliminary treatment. The details of methods of treatment have been stated earlier. When dug each tuber was carefully examined for scab spots. The scabby potatoes in each row were separated from the clean ones and both lots were counted. None of these potatoes were very badly scabbed, probably because of the light soil and dry season, so that no attempt was made to sort them as to degree of scabbiness. The details as to arrangement of the rows and condition of the crop are given in the following table. It will be seen that rows where the method of disinfection was of doubtful efficacy were separated from the adjacent rows by non-experimental rows to avoid danger of cross infection between them. The irregularities in yield were due to stumps and other unavoidable conditions which need not in our judgment be considered in weighing the results. A more critical discussion of these results is made later in this article.

FIELD I. PLAN AND RESULTS

Row No.	Treatment of seed	Variety	Total No. of tubers	No. of clean tubers	No. of scabby tubers	Per cent scabby tubers	Averages
1	Corrosive sublimate	Delaware	451	430	21	4½	6
2	Corrosive sublimate	Delaware	458	425	33	7½	
3	Formalin	Delaware	435	410	24	5½	7¼
4	Formalin	Delaware	582	530	52	9	
5	Corrosive sublimate	Rural N. Y.	366	360	6	1⅔	1⅔
6	Corrosive sublimate	Rural N. Y.	442	434	8	1⅔	
7	Formalin	Rural N. Y.	563	515	48	8½	11
8	Formalin	Rural N. Y.	593	512	81	13½	
9	Non-experimental	----------	----	----	----	------	
10	Insolation	Delaware	745	570	175	23½	18¼
11	Insolation	Delaware	1019	882	137	13	
12	Insolation	Rural N. Y.	441	363	78	17⅔	15¼
13	Insolation	Rural N. Y.	513	447	66	12⅔	
14	Non-experimental	----------	----	----	----	------	
15	Sulphur	Delaware	512	420	92	18	19
16	Sulphur	Rural N. Y.	738	590	148	20	
17	Untreated	Delaware	568	398	170	30	31¼
18	Untreated	Delaware	615	415	200	32½	
19	Untreated	Rural N. Y.	585	360	225	38	51
20	Untreated	Rural N. Y.	488	245	243	50	
21	Untreated	Rural N. Y.	487	169	318	65	

GENERAL AVERAGES

Corrosive sublimate	3⅔	per cent of tubers scabby.
Formalin	9	" " " " "
Insolation	16¾	" " " " "
Sulphur	19	" " " " "
Untreated	41	" " " " "

Field II.—Planted May 23, in drills three feet apart; dug October 1. The soil conditions of this field have been described (page 274). As there stated, it was foreseen that the results might be complicated somewhat by scab fungus already in the soil, but it was hoped that this would not be serious enough to interfere with the interpretation of the results. Examination of the table which follows shows that the entire crop was much more scabby than in Field I, and, moreover, the scabby condition of the tubers from rows where the seed was disinfected with corrosive sublimate and formalin is conclusive evidence to us that there was a considerable amount of the scab fungus in the soil. This is unfortunate in some ways since it complicates and obscures the results. There was, however, a striking difference in the *degree* of scabbiness of the tubers from the various rows. They were sorted into three grades according to this, and in our judgment the relative amount of medium and very scabby tubers is a fairly safe index to the disinfecting action of treatment upon seed. None of the tubers were injured by any treatment used except those disinfected by the sun. These were over-exposed, scorching the shoots so that very few grew. The plan of the plots and details as to results, appear in the following table. More critical discussion of these results will be given later in this article.

FIELD II. PLAN AND RESULTS

Row number	Treatment	Variety	Total number of tubers.	Number of clean tubers	No. of slightly scabby tubers	No. of medium scabby tubers	No. of very scabby tubers	Total No. of scabby tubers	Percent of scabby tubers
1	Untreated	Rural N. Y.	333	144	94	49	46	189	59
2	Untreated	Rural N. Y.	328	129	140	41	28	209	
3	Non-experimental	------	---	---	---	---	---	---	
4	Non-experimental	------	---	---	---	---	---	---	
5	Formalin, March 28	Rural N. Y.	378	227	138	11	2	151	54
6	Formalin, March 28	Rural N. Y.	365	260	102	3	0	105	
7	Formalin, May 21	Rural N. Y.	124	112	10	2	0	12	18
8	Formalin, May 21	Rural N. Y.	383	303	73	7	0	80	
9	Corrosive sublimate, May 21	Rural N. Y.	405	326	55	24	0	79	22
10	Corrosive sublimate, May 21	Rural N. Y.	397	297	297	0	0	100	
11	Untreated	Delaware	333	328	46	23	36	105	
12	Non-experimental	------	---	---	---	---	---	---	
13	Insolation	Delaware	38	32	2	4	0	6	16
14	Insolation	Rural N. Y.	74	40	18	12	4	34	46
15	Non-experimental	------	---	---	---	---	---	---	
16	Sulphur	Rural N. Y.	215	152	30	14	19	63	29
17	Non-experimental	------	---	---	---	---	---	---	
18	Sulphur fumes	Rural N. Y.	248	156	77	15	0	92	37
19	Non-experimental	------	---	---	---	---	---	---	
20	Formaldehyde gas	Rural N. Y.	312	258	39	15	0	54	17
21	Sulphur	Delaware	251	116	105	28	2	135	54
22	Non-experimental	------	---	---	---	---	---	---	
23	Formalin, March 28	Delaware	323	154	139	27	3	169	52
24	Formalin, March 28	Delaware	323	158	131	34	0	165	
25	Formalin, May 21	Delaware	278	187	73	17	1	91	38
26	Formalin, May 21	Delaware	344	196	137	11	0	148	
27	Corrosive sublimate, March 28	Delaware	312	143	105	58	6	169	56
28	Corrosive sublimate, March 28	Delaware	255	106	115	33	2	149	
29	Corrosive sublimate, May 21	Delaware	314	129	156	29	0	185	53
30	Corrosive sublimate, May 21	Delaware	223	124	62	46	11	99	

Field III.—As previously explained (page 274) this was a clay loam where a very scabby crop of potatoes was grown last year. These plots were planned on the supposition that the scab fungus was in the soil and, unless checked by some treatment, would lead to scabbiness in the crop of this season. The results showed that the fungus was there, but as will be seen no treatment tried prevented the scabbing.

Delaware potatoes were planted, and smooth seed potatoes were used in all the rows except No. 3. There were five rows, each eight rods long, planted June 7, dug October 1. The arrangement of rows and treatment of the seed was as follows :

Rows No. 1 and 2—Smooth seed, disinfected with formalin solution.

Row No. 3—Scabby seed, rolled in sulphur and sulphur scattered in the drill.

Rows No. 4 and 5—Smooth seed, disinfected with formalin and sulphur used as in row 3.

The flowers of sulphur was used very freely in rows 3, 4 and 5, at the of about 475 pounds to the acre. It was supposed from Halsted's results that this would reduce the scab to a considerable degree. We were disappointed, therefore upon digging to find that every potato in the five rows was scabby, most of them so badly as to be worthless for market purposes. Moreover there was no appreciable difference between the rows. The preservative action of the sulphur was apparent in that some of the pieces used for seed were firm and nearly or quite sound when dug up. The sulphur was also found well scattered through the soil. In many cases the tubers were visibly coated with the sulphur, showing that they had developed in intimate contact with it, and yet upon brushing this aside, scab spots were found in abundance. We are reluctantly forced therefore to the conclusion that in a badly infected soil like this, neither disinfection of the seed, nor the use of sulphur in the drill, nor both combined, can be depended upon to prevent the scab. It should be noted in this connection, however, that in Field I, where the soil was free from the fungus, the results from the use of sulphur were more favorable to it.

DISCUSSION OF THE RESULTS

The following conclusions seem justified by analyses of the results from the three fields:

1. Where the soil was free from the scab germs and scabby seed was used, a scabby crop resulted. (See Field I, rows 17-21.)

2. Where the soil was clean and the seed was properly disinfected, a practically clean crop resulted. (See Field I, rows 1-8.)

3. Where the soil was badly infected, no method of treatment was effective. (See Field III.)

4. If a soil becomes infested with the scab fungus, the fungus may persist in it for an indefinite period, even if it is not cropped with potatoes meanwhile. (See Field II, which had no potato crop for at least seven years previous to this.)

5. Corrosive sublimate and formalin in solution both proved to be excellent disinfectants, and either may be depended upon in practice. These are standard remedies whose value has been demonstrated by repeated trials and by numerous experiments. The corrosive sublimate apparently gave slightly better results in this season's trials. This is, however, to be offset against the fact that the reverse was true last season, when the formalin gave slightly better results.[1] We prefer to use formalin since it is more convenient and is non-poisonous to animals.

6. If formalin solution is used, it is better to disinfect the seed only a short time, one or two days, before planting, rather than two or three months before. A comparison of rows 7 and 8 with 5 and 6, in field II, also 25 and 26 with 23 and 24, shows that the ones disinfected just before planting,

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[1] Vt. Exp. Sta. Rpt. 11, p. 195 (1898).

were freer from scab. This was an unexpected result and may be explained in either of two or three ways, such as retention of the fungicide on the seed pieces, incomplete sterilization and subsequent recovery of the fungus, possible recontamination of the seed, etc., but whatever the explanation, the conclusion remains the same.

7. If corrosive sublimate solution is used, the sterilization may be made two months before planting time with just as good results as at a later date. (Field II, rows 27–30). The evidence from our experiments in previous years, leads us to recommend such earlier use of this solution as it may otherwise retard germination.[1]

8. Flowers of sulphur is distinctly inferior for the disinfection of badly scabbed seed to either the corrosive sublimate or the formalin solution (Field I, rows 15 and 16, and rows 1-8). Since it is also inefficient in badly contaminated soil (Field III) there seems no good reason why it should be used.

9. Exposure to the sunlight (insolation) of tubers designed for seed, for four weeks previous to planting, greatly reduced the amount of scab and gave a pretty clean crop even when very scabby seed was used. (Field I, rows 10-12 and 17-21). Since the fungus in the deeper scab spots in such scabby seed must escape the direct action of the sun's rays, it seems fair to conclude that the effect of insolation upon seed which has no deep scab spots would be proportionately much greater. Since even with the scabby seed used in Field I, insolation gave better results than the use of sulphur (300 pounds to the acre), it is a treatment of decided value. The practical merits of this treatment are also much enhanced by the fact that such exposure to sunlight so hastens the growth of the tubers that it is often practiced for this latter reason alone.

10. Exposure of seed potatoes to sulphurous gas, has been strongly advocated by Mr. Norton of Kansas. Our own trial of this (Field II, row 18) was inconclusive, owing to the fact that the soil of this plot was apparently previously infested with the scab-fungus. So far as the evidence goes, however, it indicates that this treatment is less efficacious than soaking in either corrosive sublimate or formalin or than exposing to formaldehyde gas. In our experiments the seed potatoes were not injured by exposure of twenty-four hours in an air-tight compartment in which sulphur had been burned in quantity amounting to 1 gram for 8 cubic feet of space, which is at the rate of 1 ounce of sulphur in 250 cubic feet. We consider this method worthy of further trial, but do not consider its value fully demonstrated by any evidence which has come to our knowledge.

11. Formaldehyde gas is a very powerful disinfectant, but comparatively harmless to animals and to the higher plants. Its value in disin-

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[1] Vt. Exp. Sta. Rpt. 11, p. 193 (1898).

fecting hospitals, sick-rooms and similar places where a gaseous germicide is desired, has been fully established by critical experiments. It is presumable, therefore, that it will have similar value for disinfecting seeds and plants which are not injured by it. Our trial of this for disinfecting potatoes was confined to a single row (Field II, row 20) and this was unfortunately located in the field where the soil showed evidence of previous contamination. It is not, therefore, as conclusive or satisfactory as is desirable. It is significant, however, that it gave the *best results of the entire field, being superior to both the formalin and corrosive sublimate solutions.* While we do not feel justified in recommending it as a substitute for these standard remedies on the strength of this one trial, we do believe that there is reason to hope that further trial will prove that it has great practical value. Its experimental use is, therefore, strongly commended.

LEAF-SCORCHING OF TREES BY THE WIND[1]

About July first, 1900, there occurred a sudden and peculiar "blighting" of the leaves of many trees and shrubs. It was first noticed that the leaves were dying on one side of an elderberry at the Experiment station farm. Examination showed that it was not because of insect or fungus attacks. Further observation revealed similar troubles upon numerous other neighboring trees and shrubs, and here again it was only the one side, the west, that was blighting. With the elderberry and similar slender leaf blades, the blighting began at the tips and margins. The broader leaves, like maple, frequently showed dead margins also, but dead spots occurred in addition scattered irregularly between the larger veins. Numerous inquiries, with similar specimens, came from other parts of the Champlain valley, indicating that the trouble was wide spread.

We have since had opportunity to observe it in many cases, and the characters already noted have held good. In one case, a whole line of maple shade trees was seen where the west side appeared as if scorched by fire, though the east side was not harmed. The outer trees along the west margins of woodlands suffered noticeably. Maples were affected most, but similar injury was observed on many of the other deciduous trees including beech, oak, hop-hornbeam, elm, hickory, ash and fruit trees. One fruit grower reported serious injury to young plums.

The cause.—The injury was unquestionably the result of a peculiar combination of weather conditions. The last ten days of June were continuously clear, bright, hot and dry. Several days before the injury was seen, an unusually heavy, dry, west wind blew throughout one day, accompanied by hot sunshine. It was then that the injury occurred. It was due to excessive loss of water through transpiration induced by this wind, and so differed somewhat from the more usual leaf-scorch which is primarily attributable to the hot sun. This wind could hardly have caused the trouble, however, had not the preceding dry, bright, hot days reduced the water content of the plant to a low point. Trees that were sheltered from the wind escaped, as did many of those exposed where the soil conditions were especially favorable. The occurrence of the injury almost wholly on the west side of the plants is, of course, in part, attributable to the greater exposure of that side to the westerly wind. The full explanation is probably to be found, however, in the fact that the hot, bright rays of the afternoon sun were combined with the west wind in hastening transpiration.

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[1] The account is based on observations and conclusions of A. W. Edson, now assistant botanist.

At this same time many young shade and fruit trees died. In some places this same wind blasted the rose-buds, by drying their outer petals so that they died, and the normal development of the flowers was prevented, although the green leaves were not injured. With the exception of trees recently transplanted, there will probably be little permanent injury.

KILLING WEEDS WITH CHEMICALS

I. SULPHURIC ACID COMPARED WITH SALT FOR THE ORANGE HAWKWEED

Investigation at this station upon the orange hawkweed[1] has shown that salt applied at the rate of one to two tons to the acre will kill it, and that this amount of salt does not seriously injure the grass, at least on clay soil. Many correspondents, following these directions, have used salt with success in destroying this weed. Occasionally, however, some one writes that this remedy has failed. In a letter recently received from New York it was stated that sulphuric acid, 1 part in 40 parts of water, had proved efficient, while salt had not. It seemed desirable, therefore, to repeat the experiments with salt and to test the sulphuric acid in comparison.

July 19, sulphuric acid, diluted as above, was applied to a plot of almost pure hawkweed. About four gallons was used to the square rod which sufficied to wet all the plants thoroughly. The effect was immediate. Every plant of weed and grass on the plot blackened and apparently died. The leaves bleached in the next few days so that the plot became very conspicuous and it certainly looked as if the sulphuric acid treatment was a success. On July 27 it was noticed, however, that the hawkweed plants were recovering. The dead leaves had mostly disappeared by this time. But from the crown of each apparently dead plant, tiny green leaves were being sent out. Evidently the plants were going to recover.

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[1] Vt. Sta. Rpt. 10, p. 62, (1896).

As there had been considerable rain since this application was made, it was thought best to give the acid another trial, and also to compare its action more directly with that of salt. Accordingly six plots were measured out and applications were made July 27, in the following amounts to the square rod :

Plot 1. 1 part sulphuric acid in 80 parts water, 4 gallons per square rod.
" 2. 12 pounds salt.. " " "
" 3. 1 part sulphuric acid in 40 parts water, 1 gallon " " "
" 4. 1 " " " " 60 " " 2 " " " "
" 5. 25 pounds salt.. " " "
" 6. 1 part sulphuric acid in 40 parts water, 2 gallons " " "

The sulphuric acid had, in all cases, the same immediate effect as before, while the salt was more slow in its action. On August 3, one week later, the plots were carefully examined and compared.

In plot 1 (acid) the plants seemed entirely killed, except that a very few showed life in the crown. The grass also seemed killed.

Plot 2 (salt) there was not a green part left to any hawkweed. The grass and clover plants were not killed.

Plot 3 (acid), only about one-half the hawkweeds were killed.

Plot 4 (acid) was not quite so good as plot 1.

Plot 5 (salt), every weed was killed and some grass was left.

Plot 6 (acid) was not quite so good as 4.

On August 9, the plants in the four plots treated with sulphuric acid were sending out new leaves at the crown.

In plot 2 but one live hawkweed could be found ; grass was doing well. In plot 5 not a single hawkweed remained. From this time on the hawkweed gradually recovered in plots treated with sulphuric acid, while those treated with salt remained practically free from the weed.

September 5, when the final notes were taken the sulphuric acid plots were scarcely distinguishable from the untreated ground about them, being entirely covered with the weed. The salt plots were in striking contrast, there being but half a dozen hawkweed plants alive in plot 2, and not a single one could be found in plot 5. The grass on both of these salt plots continued to make a good growth.

These results indicate that sulphuric acid is not to be compared with salt as a remedy for the hawkweed. With more confidence than ever, we can say that salt is the best chemical yet tried for killing hawkweed and that, when properly used it is entirely effective.

In closing, we will repeat what we have frequently stated regarding the use of salt. Salt kills the hawkweed by drawing water from its tissues rather than by any poisonous or toxic action. To succeed, therefore, the salt should be applied dry (not as a brine) and upon a hot, sunshiny day, preferably during a period of dry weather. Scatter it uniformly, broadcast, so as to come in contact with all the plants, using from 12 to 18 pounds to the square rod, which is equivalent to one ton or one and one-half tons to the acre. We also would emphasize again the fact that this weed is easily killed by cultivation where that it is practicable, and that the use of salt is recommended only for isolated patches of the weed or in soil where cultivation is impracticable.

II. KILLING KALE WITH COPPER SULPHATE

The use of copper sulphate as a spray for killing charlock and other weeds, has been advocated for several years past in Europe and Australia.[1] In this country it has been favorably reported upon by at least two experimenters.[2]

The concensus of these results is that certain weeds are readily destroyed when in the earlier stages of their development, by spraying with copper sulphate, 1 to 5 percent solutions, 40 to 50 gallons to the acre, and that cereals such as wheat, barley and oats are but slightly injured by such spraying.

The weed for which this spraying has been most generally recommended is charlock, *Brassica Sinapistrum*. This is one of the four weeds which pass in Vermont under the common name of "kale."

The other three "kales" are wild turnip, *B. campestris*, black mustard, *B. nigra*, and indian mustard, *B. juncea*. Of these the last two are not as yet common enough to rank as serious pests but the wild turnip vies with the charlock as a weed in many Vermont grain fields.

These two may be distinguished by the fact that the charlock has leaves more or less hairy and rough to the touch, whereas the leaves of the wild turnip are smooth and glaucous, that is to say, they have a bluish-white bloom upon the surface as in the cultivated turnip and rutabaga. The wild turnip also differs from the other three in that its upper leaves are sessile and auricled, that is, they are without leaf-stem and have two ear-like lobes at the base which clasp the main stem on either side, whereas, in the other three species, these upper leaves have distinct petioles or leaf-stems.

It was thought desirable to make trial of the copper sulphate spray upon these "kales" in order to verify the favorable conclusions reached by other experimenters, and also to learn whether this remedy, which has proved so effective for charlock, is equally useful in destroying the wild turnip. Accordingly on June 13 three plots—numbers 1, 2 and 3 of the table which follows, each one rod square, were staked out in a field of oats in which there were many "kale" plants. The oat plants were only three or four inches high. The "kales" included the desired two species, charlock and wild turnip. The plants were mostly from three to six inches high. About one-half had formed the basal leaves only, some were budded but none were in blossom. The applications were made about three o'clock in the afternoon of a bright warm day. During the following night there were heavy showers which, no doubt, modified the results on these plots. The solutions used were three and five percent.

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[1] See Exp. Sta. Rec. 10, p. 1049 : (1899) 11, p. 461 and p. 856 (1899-1900).

[2] Bolley, H. L., Proc. Soc. Prom. Ag. Sci. 20, p, 107 (1899).
Shutt, F. T., Canada Exp. Farms, Rpt. for 1899 p. 194.

Three hours after the applications were made the plants seemed to be considerably affected. Two days later, on June 15, some of the plants were dead and a large number of the others were evidently dying as the leaves were badly spotted and the edges curled and dead. On the ninth day, June 22, approximately one-fourth of the plants were entirely dead, one-half were affected and one-fourth seemed to be uninjured. July 5, one-half of the plants were entirely killed. The results are summarized in the table at the end of this article.

June 23 another application was made to plot 3 and two more similar plots, 4 and 5, were staked out and sprayed. The applications were made at nine o'clock in the morning. The day was very bright and sunny with a hot dry wind. There was no rain for several days following. The plants were somewhat larger than when the other plots were sprayed, many of them being in bud or early blossom. The larger size of the kale plants and the fact that they were somewhat shielded by the oats which were now ten inches high, both tended to lessen the destruction of the kale by the solution. But the results were more satisfactory than from the earlier spraying, owing to the favorable weather conditions.

As shown in the table below nearly 70 percent of the plants were killed and still others injured. It was observed that in many cases where the spray did not entirely destroy the kale plants it was only the lower leaves that survived. This was almost equal as a practical result to the death of the plant since such plants matured little or no seed.

Unfortunately no separate record was made of the exact numbers of charlock and of wild turnip in these plots. The general behavior of the two weeds under the treatment was, however, observed. Practically every plant of charlock was killed by the spraying of June 23 and most were killed by that of June 13. The wild turnip was more resistant. This was apparently due to the smoothness and "bloom" of the leaves since the solution rolled off the plants entirely or gathered in drops as if on an oiled surface. Most of the plants that survived the spraying were of this species, and, so far as could be estimated at the close of the experiment, not over one half of the wild turnip plants on the five plots had been killed. The oat plants were slightly injured especially by the stronger solution but soon entirely recovered. The injury to them was not enough to be taken into practical consideration.

These results are in accord with all the previous trials reported so far as concerns the charlock and it may be stated with confidence that this kind of " kale" can be destroyed by spraying with a weak solution of copper sulphate. It is recommended that the solution contain about 1 pound of sulphate to 4 gallons of water if the charlock plants are so old as to have thrown up flower stalks—and 1 pound to 6 gallons if they are younger. The earlier applications will probably prove the more desirable. Some European experimenters even recommend that such an early application be soon followed by a second spraying. The solution should be applied with a spray pump supplied with a fine nozzle. With this it requires from 30 to 60 gallons (approximately one barrel) to the acre.

Since copper sulphate costs but 5 to 10 cents a pound the expense, other than for labor, is small and the operation may in many cases be a profitable one. Anyone contemplating the trial should, however, first examine his kale plants carefully and determine that they are the charlock rather than the wild turnip, since it is questionable if the treatment will pay upon the latter plant.

In conclusion, however, we wish to add our conviction, that the preferable way to handle kale and most other weeds in tillable land is, in general, not by the use of chemicals but by shorter rotations, more clover and corn, and cleaner cultivation.

SUMMARY OF EFFECTS OF SPRAYING UPON KALE PLANTS

Plot	I			II			III			IV			V		
Solution used	5% Copper Sulphate			3% Copper Sulphate			3% Copper Sulphate			3% Copper Sulphate			3% Copper Sulphate		
Date when sprayed	June 13			June 13			June 13 June 23			June 23			June 23		
No. of kale plants when sprayed	136			130			115			92			86		
Condition of kale plants on following dates	Uninjured	Affected	Dead	Uninjured	Affected	Dead	Uninjured	Affected	Dead	Uninjured	Affected	Dead	Uninjured	Affected	Dead
June 15	3														
June 23	31	73	32	18	66	46	17	87	1						
July 5	31	53	52	18	60	52	17	15	83	11	21	58	19	9	58

IMPURITIES OF GRASS AND CLOVER SEEDS

The botanical department is called upon with increasing frequency, to give advice regarding recently introduced plants which threaten to become weeds. Grass and clover seeds constitute the principal channel of introduction of such plants. The more careful farmers appreciate this and often ask the station for advice relating to seed purchases. The matter of weed legislation and official inspection of agricultural seeds has come up for discussion before recent legislative committees, and they also have asked the station for advice. Seed inspection is not the highest type of experiment station work, but it has seemed wise, in view of these facts, to give at least so much time to it as is necessary properly to answer such questions. This requires a knowledge of the kind and amount of impurities occurring in the average seeds offered for sale in the state. A beginning was made in the acquisition of such knowledge in 1897, when examinations were made of samples of clover and grass seeds contributed by twenty-five farmers from various localities in the state. The results of this inspection may be found in the eleventh annual report of the Vermont experiment station, page 229. Wishing to extend this investigation, the station last spring sent a request for samples of seed to over one hundred farmers throughout the state. In each case the request was made that these samples be so collected as to fairly represent the seeds furnished to the farmers of the community. The responses were very generous, resulting in over two hundred samples of alsike and red clover, of timothy and other grass seeds. The seeds of timothy and of red clover so obtained have been carefully examined as to purity.[1] Examinations of the others are under way but are not as yet completed. In accordance with the regulations governing seed tests made by the Department of agriculture, five-gram samples of clover were taken and two-gram samples of timothy. The impurities were divided into two classes: (1) *Inert matter*, including chaff, straws, dirt, broken seeds, &c.; (2) *Viable seeds*, including all foreign seeds which were apparently sound. These two classes of impurities were then weighed separately, and the results of such weights are expressed in percents in the tables. The viable seeds were further sorted, the species of each kind determined and the number counted. These foreign seeds are for practical purposes readily divisible into two classes: useful seeds, including the valuable grasses and clovers; and noxious seeds, including the weedy plants. The importance of this division is evidently great, and in tabulating the results we have so differentiated them. The results of the examinations are shown in the following tables:

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[1] To obtain full data for determining the value of seed it is also necessary to make germination tests. It was not possible to do this in the case of these samples, nor has the station as yet considered it expedient to offer to do this for farmers. Satisfactory germination tests can be made by anyone by simply placing seeds between two pieces of moist flannel, at the temperature of the ordinary living room. The flannel may by inclosed between two plates to prevent drying.

TABLE I. IMPURITIES IN RED CLOVER

Sample number	Sent by	Where bought	Price in cents per pound	Percent total impurities	Percent inert matter	Percent foreign seeds	Detailed statement of kind and number of foreign seeds in 5 grams																																			
							Noxious foreign seeds																														Useful foreign seeds						
							Chickweed	Red-root	Roman Wormwood	May weed	Charlock	Self-Heal	Yellow Foxtail	Green Foxtail	German Mil'et	Pigweed	Canada Thistle	White Daisy	Spurge	Spotted Spurge	Pepper-grass	Hair-grass	Barn-yard grass	Small Crab-grass	Crab-grass	Paspalum	Bracted Plantain	English Plantain	Common Plantain	Red-stem Plantain	Smart-weed	Sheep Sorrel	Curled Dock	Penny Cress	Vervain	Alfalfa	Millet	Timothy	White Clover	Alsike Clover	Grass Sp. undetermined	Seeds undetermined
1	O. T. Ware	Brattleboro	12	0	0	0	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2	W. O. Hinds	Bridport	10½	14.	1.4	13.6	--	--	--	--	15	--	--	112	--	84	--	--	--	--	--	--	--	--	--	--	7	4	--	38	13	9	22	--	--	--	--	540	--	--	2	8
3	" "	"	9½	3.5	.7	2.8	--	2	--	--	5	--	--	21	--	--	--	--	--	--	--	--	--	--	--	--	1	7	--	21	--	--	4	--	--	--	--	22	--	--	--	--
4	B. W. Crane	Troy, N. Y.	8½	2.5	.7	1.8	--	--	--	--	--	--	--	9	--	5	--	--	--	--	--	3	--	--	--	--	1	4	--	22	2	--	5	--	1	--	--	7	--	--	1	1
5	" "	" "	9	2.	.5	1.5	--	3	--	--	--	--	--	19	--	--	--	--	--	--	--	--	--	--	--	--	1	2	--	17	--	2	3	--	--	--	--	11	--	--	--	--
6	J. B. Peckham	Montpelier	10	1.6	.5	1.1	--	--	--	--	--	--	--	20	--	--	--	--	--	--	--	--	--	--	--	--	1	1	--	11	2	3	2	--	--	--	--	2	--	--	--	1
7	L. C. Fisher	Portland, Me.	8½	3.3	.4	2.9	--	--	--	--	1	--	--	50	--	8	--	--	--	--	--	--	--	--	1	--	2	7	--	5	7	1	1	--	--	--	--	18	--	--	--	--
8	" "	" "	12	6.6	1.1	5.5	--	--	--	--	7	--	--	104	--	7	--	--	--	--	--	--	--	--	2	16	1	--	--	2	10	3	11	--	--	--	--	56	--	--	--	--
9	L. Putnam	Cambridge	11	4.2	.6	3.6	--	1	--	--	--	--	--	42	--	21	--	--	--	--	--	--	--	6	1	7	2	5	--	18	2	9	2	--	--	--	--	73	--	--	--	--
10	John Mitchell	Fairfield	9 1-6	6.	1.2	5 8	--	--	--	--	11	--	--	102	--	26	--	--	--	--	--	--	--	--	--	6	2	1	--	3	--	4	7	--	--	2	--	55	--	2	--	--
11	G. T. Alpin	Brattleboro	9	6.	1.	5.	--	9	--	--	--	--	6	48	--	28	--	--	--	--	--	4	--	--	--	--	--	--	--	16	11	2	2	--	1	--	--	65	--	--	6	4
12	" "	"	10	.6	.1	.5	--	2	--	--	6	--	--	4	--	--	--	--	--	--	--	1	1	--	--	--	--	--	--	9	2	--	1	--	--	--	--	--	--	--	--	--
13	Dix J. Camp	E. Randolph	10½	2.5	.5	2.	--	--	--	--	--	--	--	19	--	--	--	--	--	--	--	2	2	--	--	--	--	1	--	16	--	8	2	--	--	--	--	31	--	--	2	1
14	Clarence Bedell	E. Ryegate	10	7.5	1.1	6.5	--	--	--	--	10	--	--	85	--	44	--	--	--	--	--	--	--	--	--	9	3	--	--	3	15	8	6	--	--	--	--	85	--	--	--	--
15	M. P. Perley & Co.	Enosburgh Falls	10	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
16	J. B. Maxfield	Cambridge	10	2.9	1.	1.9	--	5	--	--	--	--	--	15	--	9	--	--	--	--	--	--	--	--	--	--	2	3	--	15	3	--	3	--	--	--	--	24	--	--	2	--
17	L. H. Sheldon	Fairhaven	-----	0.5	0	0.5	--	--	--	--	--	--	1	1	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	5	--	--	--	--	--	--	--	--	--	--	--
18	" "	"	10	0.5	---	0.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	2	--	--	--	--	4	--	2	--	--	--	--	--	--	--	--	--
19	W. F. Clark	Glover	10	1.7	.4	1.3	--	--	--	--	--	--	3	--	--	--	--	1	--	--	--	4	--	--	6	--	4	7	--	16	--	--	1	--	--	--	--	--	--	--	--	--
20	L. J. Sanderson	Highgate	10	8.2	2.	6.2	--	4	--	--	1	--	1	39	--	16	--	--	--	--	--	--	1	1	1	5	2	3	--	25	4	6	9	--	--	--	--	90	--	--	--	--
21	L. W. Barton	Ludlow	10	3.5	.6	2.9	--	3	--	--	4	--	--	33	--	6	--	--	--	--	--	--	--	--	1	5	4	2	--	7	11	--	--	--	--	--	--	15	--	--	--	--
22	L. B. Harris	Lyndonville	10	5.2	.8	4.4	--	20	--	2	--	--	2	4	--	--	--	--	4	--	--	3	--	1	--	2	3	20	--	36	12	7	14	--	--	--	--	94	--	--	--	4
23	U. M. Canfield	Manchester	9½	.1	.1	---	--	--	--	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--
24	" "	"	10	.3	.3	---	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
25	C. F. Smith	Chicago	10	2.2	.4	1.8	--	--	--	--	--	--	--	10	--	10	--	--	--	--	--	2	--	1	1	--	5	6	--	15	2	4	2	--	--	--	--	48	--	--	--	--
26	" "	Morrisville	10	7.4	1.	6.4	--	1	--	--	6	--	2	75	--	50	--	--	--	--	--	--	--	--	1	4	1	6	--	5	6	5	5	1	--	--	--	114	--	--	--	--
27	M. O. Howe	Newfane	10	5.	.6	4.4	--	3	--	--	--	--	--	29	--	33	--	--	--	--	--	2	--	--	2	--	5	7	--	44	--	5	1	--	--	--	--	51	--	--	1	2
28	J. C. Wilder	New Haven	11	3.6	.8	2.8	--	3	--	--	--	--	--	23	--	7	--	--	--	--	--	2	--	--	2	--	1	2	--	19	1	10	4	--	--	--	--	62	--	--	--	--

29	J. C. Wilder	Vergennes	10½	2.7	.4	2.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	5	--	17	--	--	--	--	--	--	--	196	--	--	--	1
30	L. M. Macomber	N. Ferrisburgh	12	.6	.3	.3	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	13	--	--	--	--
31	F. L. Davis	Woodstock	7½	6.2	1.4	4.8	--	7	--	--	1	--	2	35	--	1	1	--	--	--	--	5	1	4	2	4	1	--	--	18	14	6	--	--	--	6	1	105	--	--	--	--
32	" "	"	10½	.9	.4	.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	9	3	18	--	--	--	--	--	--	--	--	--	--	--	--
33	J. R. Kenerson	Peacham	10	8.	.6	7.4	--	10	--	4	--	--	1	28	--	24	--	--	--	--	--	3	1	10	5	4	2	3	--	66	--	17	--	--	--	7	--	230	--	--	--	--
†34	" "	"	9	11.6	11.1	.5	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	6	2	--	--	--	--	2	--	6	--	--	1	--
35	Edwd. Gordon	Plattsburgh, N. Y.	10	7.2	1.	6.2	--	--	--	1	--	--	--	32	--	29	--	--	--	--	--	2	1	1	--	--	1	--	--	50	6	17	--	--	--	4	--	241	--	--	1	--
36	" "	Burlington	--	.5	0	.5	--	--	--	--	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	13	--	--	--	--	1	--	--	--	--
37	" "	Plattsburgh, N. Y.	9	4.	.4	8.6	--	--	1	--	--	--	--	12	--	--	--	--	--	--	--	1	--	--	--	--	--	13	--	3	4	--	3	--	--	--	--	105	--	--	--	--
38	C. K. & A. B. Hawkins		--	0	0	0	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--
39	E. Hitchcock	Rutland	10	5.3	.6	4.7	--	4	--	--	--	--	--	24	--	1	--	--	--	1	--	4	--	1	2	1	1	2	--	29	--	6	42	--	--	3	--	50	2	--	--	--
40	F. W. Spaulding	Poultney	10	3	.5	2.5	--	1	--	--	--	--	--	39	--	--	--	--	--	--	--	1	--	--	1	1	--	1	--	14	1	1	16	--	--	1	--	19	6	--	--	--
41	J. B. Gorham	Putney	10	7.7	.8	6.9	--	4	--	--	--	--	2	57	--	20	--	--	--	--	--	2	1	--	--	8	--	2	--	48	7	34	27	--	--	6	--	83	7	6	--	4
42	" "	"	--	3.4	.8	2.6	--	--	1	--	--	--	--	14	--	1	--	--	--	--	--	1	1	3	--	5	--	3	--	6	1	4	9	--	--	1	--	39	7	--	--	--
43	D. H. Morse	Randolph	9	4.7	1.	3.7	--	7	--	--	1	--	--	27	--	10	--	--	--	--	--	5	--	8	--	--	--	--	--	43	3	7	9	--	--	2	--	117	7	--	--	2
44	" "	"	10	2.9	.5	2.4	--	--	1	--	--	--	--	6	--	2	--	--	--	--	--	--	--	1	--	2	--	--	--	9	--	--	15	--	--	--	--	9	24	--	--	--
45	" "	"	10	2.4	.6	1.8	--	1	--	--	--	--	1	15	--	--	--	--	--	--	--	--	--	--	1	3	--	--	--	3	4	2	20	--	--	--	--	7	3	--	--	--
46	" "	"	10	2.1	.6	1.5	--	--	--	--	--	--	2	9	--	1	--	--	--	--	--	--	--	1	--	3	--	1	--	8	1	1	10	--	--	--	--	8	2	7	--	3
47	Alpha Messer	Rochester	15	.5	.0	.5	--	--	--	--	--	--	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	2	--	2	--	--	--	--	2	4	--	--	3
48	" "	"	11	1.8	.2	1.6	--	--	--	--	--	--	--	15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--	4	--	9	--	--	1	--	--	2	--	--	--
49	" "	"	10	8.	1.7	6.3	--	--	--	4	--	--	8	17	--	1	--	--	--	--	1	3	--	--	--	--	--	--	--	182	--	1	--	--	--	6	--	--	--	--	--	--
50	D. K. Hall	Rutland	9½	1.7	.0	1.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	12	--	7	--	1	6	--	--	1	--	95	--	--	--	2
51	" "	"	11	.5	.0	.5	--	1	--	--	--	--	--	5	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	15	--	--	--	--	--	1	--	--	--
52	" "	"	8½	1.6	.3	1.3	--	--	--	--	--	--	--	--	4	--	--	--	--	--	--	--	--	--	--	--	4	12	--	5	--	1	9	--	--	--	--	6	--	--	1	4
53	" "	"	9	.5	.1	.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	8	--	--	--
54	E. S. Brigham	St. Albans	11	2.7	.1	2.6	--	--	--	2	--	--	--	12	--	--	--	--	--	--	--	--	--	1	--	--	2	31	--	14	3	1	--	--	--	--	--	20	--	--	--	--
55	" "	" "	12	5.6	.4	5.2	1	4	--	3	--	--	--	10	--	20	--	--	1	--	2	9	--	--	--	1	--	--	--	5	--	41	10	1	--	--	1	170	29	--	--	--
56	H. C. Bruce	Sharon	10	.7	.4	.3	--	--	--	--	--	--	--	14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	1	2	--	1	--	--	--	1	--	--	--
57	" "	"	10	5.4	.9	4.5	--	8	--	5	--	--	--	9	--	1	--	--	4	--	--	4	--	6	--	7	7	2	--	31	7	32	9	--	--	10	--	57	7	--	1	5
58	R. H. Holmes	Shoreham	10	1.2	.4	.8	--	--	--	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--	2	7	--	--	12	--	--	5	--	--	--	--	4	4	--	--	--
59	" "	"	10	.5	.2	.3	--	--	--	--	--	--	--	4	--	--	--	--	--	--	--	--	1	--	--	4	--	--	--	--	2	--	--	--	--	2	--	--	--	--	--	2
60	F. B. Pier	Brattleboro	7½	2.6	.9	1.7	--	2	--	--	2	--	--	18	--	2	--	--	--	--	--	2	--	2	--	4	--	--	--	5	5	3	5	--	--	--	--	33	4	--	--	--
61	L. M. Cragin	Springfield	11	10.9	1.4	8.6	1	--	--	--	15	--	--	80	--	42	--	--	--	--	--	--	--	--	--	6	2	3	--	2	20	8	--	--	--	8	--	110	5	--	--	3
62	" "	"	10	.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--	2	--	2	5	1	--	--	--	--	--	3	--	--	--	--
63	" "	"	10	2.9	.6	2.3	1	5	--	2	--	--	--	20	--	7	--	--	--	--	--	1	--	1	--	1	--	1	--	8	8	8	1	--	--	6	--	72	17	8	--	6
64	J. S. Woodard	Brattleboro	12	.7	.2	.5	--	--	--	--	--	--	--	2	--	2	--	--	--	--	--	--	--	--	--	--	--	2	--	5	--	1	--	--	--	--	--	12	--	--	3	2
65	E. O. Lee	Buffalo, N. Y.	10	.3	.1	.2	--	--	--	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	3	--	--	--	--
66	F. S. Hale	Windsor	10	5.5	.7	4.8	--	15	--	--	--	--	--	28	--	6	--	--	--	--	--	1	1	16	1	6	--	--	--	25	5	--	33	--	--	--	--	99	3	--	--	--
67	Geo. Aitken	Woodstock	11	4.4	.2	2.2	1	1	--	1	--	--	2	32	--	22	--	--	1	--	--	2	1	6	--	2	--	11	--	22	--	12	20	--	--	4	--	120	--	--	--	9
68	" "	"	11	1.6	.3	1.3	--	1	--	--	--	--	--	5	--	5	--	--	--	--	--	--	--	1	--	--	--	1	--	--	2	--	4	--	--	7	--	8	15	--	1	--
69	L. W. English	"	10	5.9	.1	4.9	--	10	--	--	--	--	--	24	--	22	--	--	--	--	--	3	--	5	--	2	--	1	6	11	4	5	--	--	--	2	--	197	--	--	--	--
70	H. M. Pearl	Plattsburgh, N. Y.	10	.4	.3	.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4	5	--	--	--	--	--	--	--	1	--	--	--	--	--	--
71	" "	Ravena, Ohio	7½	1.2	.1	1.1	--	1	--	--	--	1	--	10	--	--	--	--	2	1	--	1	--	--	3	1	--	--	--	18	1	--	10	1	--	--	--	6	--	--	2	1
72	D. K. Hall	Rutland	8½	2.2	.4	1.8	--	--	--	--	--	--	--	20	--	--	--	--	--	--	--	--	--	--	2	4	--	3	--	14	--	5	13	--	--	--	--	11	--	--	--	--
73	C. K. & A. B. Hawkins	Troy, N. Y.	--	2.4	.7	1.7	--	--	--	--	--	--	--	9	--	..	--	--	--	--	--	1	1	3	2	7	--	1	--	15	1	4	6	--	--	5	--	1	--	--	--	--
74	" " "	" "	--	1.3	--	1.3	--	--	--	--	--	--	--	12	--	1	--	--	--	--	--	--	--	--	--	--	--	3	--	2	3	--	--	--	--	--	--	2	3	--	--	--

† 10.7 per cent of this impurity was inert alfalfa seed.

TABLE II. IMPURITIES IN TIMOTHY SEED

Sample number	Sent by	Where bought	Price per bushel in dollars	Percent of total impurities	Percent of inert matter	Percent of foreign seeds	Number noxious foreign seeds in two grams	Number useful foreign seeds in two grams	Number of kinds of weed seeds in two grams	Detailed statement of kind and number of foreign seeds in 2 grams																			
										Noxious foreign seeds																Useful foreign seeds			
										Red-root	May-weed	Green foxtail	Pigweed	Charlock	Pepper-grass	Evening primrose	Hair-grass	Common plantain	Red-stem plantain	Purslane	Five finger	Sheep sorrel	Curled dock	Yellow daisy	Vervain	Red Top	Alsike clover	White clover	Red clover
1	C. M. Winslow	Brandon	1.75	.5	.5	.0	1	1	1	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	1	--	--
2	" "	"	1.75	.5	.5	.0	0	2	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3	" "	"	1.80	.2	.2	.0	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4	Geo. Pierce	Brattleboro	1.90	.4	.2	.2	1	2	1	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	2	--	--
5	" "	"	1.50	.6	.3	.3	2	6	2	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6	--
6	W. O. Hinds	Vergennes	1.65	.5	.5	.0	0	1	0	--	--	--	3	--	--	--	1	--	--	--	--	1	--	--	--	1	1	1	--
7	" "	Bridport	1.40	1.	.4	.6	5	3	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--
8	B. C. Crane	Bridport	1.45	1.	.5	.5	9	3	2	--	--	--	2	--	--	--	7	--	--	--	--	--	--	--	--	--	--	3	--
9	J. B. Peckham	Montpelier	1.55	.75	.5	.25	2	4	1	--	--	--	--	--	--	--	--	--	--	--	--	1	1	--	--	--	2	2	--
10	L. C. Fisher	Portland, Me.	1.60	.75	.5	.25	9	1	3	--	--	--	--	--	--	7	1	--	--	--	--	--	--	1	--	--	--	1	--
11	L. Putnam	Cambridge	2.00	.4	.4	.0	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
12	John Mitchell	Fairfield	2.00	.25	.0	.0	0	1	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--
13	" "	"	1.50	1.	.5	.5	17	7	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8	--	--	--	3	--
14	" "	Burlington	1.65	.6	.4	.2	8	3	1	--	--	--	6	--	3	2	--	--	--	5	--	--	--	1	--	--	5	2	--
15	G. T. Alpine	Brattleboro	1.60	.5	.3	.2	8	4	4	--	--	--	1	--	--	1	--	--	2	--	--	--	--	4	--	--	2	2	--
16	" "	"	1.75	.2	.1	.1	2	3	1	--	--	--	--	--	--	--	--	--	--	--	--	2	--	--	--	--	--	3	--
17	Dix J. Camp	E. Randolph	1.40	.4	.2	.2	2	7	2	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	1	--	4	3	--
18	" "	"	2.00	.25	.25	.0	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
19	Clarence Bedell	E. Ryegate	1.45	.5	.25	.25	11	3	3	--	--	--	6	--	3	--	--	--	--	--	--	--	--	--	2	--	3	--	--
20	L. W. English	Woodstock	1.50	7.	4.5	2.5	235	13	7	--	--	--	1	--	20	--	--	--	15	--	190	1	--	8	--	--	--	13	--
21	Geo. Aitken	"	1.50	1.	.5	.5	20	11	6	--	--	--	5	--	2	--	--	--	--	--	1	5	--	6	1	--	--	11	--
22	F. S. Hale	Windsor	1.50	1.5	.5	1.	43	10	5	--	--	--	--	--	--	5	--	--	5	--	27	--	--	5	1	--	3	7	--
23	E. O. Lee	Vernon	1.45	2.	1.5	.5	25	4	7	--	--	--	9	--	2	--	1	--	2	--	8	--	--	2	1	--	--	4	--
24	E. M. Bissell	Shoreham	1.50	1.5	1.	.5	41	7	4	--	--	--	1	--	--	9	--	--	1	--	30	--	--	--	--	--	--	7	--
25	M. P. Perley & Co.	Enosburgh Falls	1.90	.4	.4	.0	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

26	“ “ “	“ “	2.00	.3	.3	.0	0	1	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--
27	“ “ “	“ “	2.40	.4	.2	.2	3	3	1	--	--	--	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	--
28	“ “ “	“ “	1 50	1.	.7	.3	7	2	5	--	--	--	--	--	--	--	--	--	1	1	2	1	--	2	--	--	2	--	--
29	J. B. Maxfield	Cambridge	1.75	2.5	2.	.5	55	1	5	--	--	--	9	--	3	--	--	--	6	--	32	--	--	5	--	--	--	1	--
30	“ “	“	2.00	.5	.3	.2	5	4	3	--	--	--	--	--	2	--	--	--	2	--	--	--	--	1	--	--	--	4	--
31	L. H. Sheldon	Fairhaven	1.45	.5	.3	.2	16	1	5	--	--	--	3	--	2	--	--	--	4	--	6	--	--	1	--	--	--	1	--
32	L. H. Sheldon	Fairhaven	1.75	.2	.2	.0	2	0	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--	--	--	--	--
33	W. F. Clark	Glover	1.50	1.5	1.	.5	19	14	9	--	--	3	1	--	1	4	--	--	2	1	2	--	--	4	1	--	3	11	--
34	L. J. Sanderson	----	1.60	6.5	5.	1.5	123	0	8	--	--	--	14	--	8	13	--	--	7	--	68	1	--	9	3	--	--	--	--
35	“ “		1.75	.6	.35	.25	15	2	6	--	--	--	5	--	1	1	--	--	1	--	6	--	--	1	--	--	--	2	--
36	“ “		1.60	1.	.5	.5	27	6	3	--	--	--	--	--	1	--	--	--	2	--	6	3	--	13	2	--	--	3	--
37	L. W. Barton	Ludlow	1.50	1.	.5	.5	21	6	4	--	--	--	--	--	--	1	--	--	--	--	11	--	--	7	2	--	--	6	--
38	“ “	“	2.00	.3	.3	.0	1	2	1	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	2	--
39	“ “	“	1 50	.2	.0	.2	2	2	1	--	--	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	2	--	--
40	L. B. Harris	Lyndonville	1.50	2.	.75	1.25	25	20	4	--	--	--	--	--	--	--	--	2	--	--	13	5	--	5	--	--	1	18	1
41	U. M. Canfield	Manchester	1.50	.7	.7	.0	3	0	3	--	--	--	--	--	1	--	--	--	--	--	1	--	--	1	--	--	--	--	--
42	C. F. Smith	Morrisville	1.60	.9	.7	.2	7	1	1	1	--	--	1	--	--	--	--	4	--	--	--	--	--	1	--	--	1	--	--
43	“ “	“	2.00	.1	.1	.0	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
44	M. O. Howe	Newfane	1.50	1.	.8	.2	6	0	3	--	--	--	2	--	--	--	--	2	--	--	--	--	--	2	--	--	--	--	--
45	J. C. Wilder	New Haven	--	1.25	1.2	.05	7	0	4	--	--	--	1	--	4	--	--	--	--	--	1	--	--	1	--	--	--	--	--
46	“ “	Vergennes	1.80	.4	.4	.0	1	0	1	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--
47	D. C. Hicks	No. Clarendon	1.75	.2	.2	.0	1	0	1	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
48	L. M. Macomber	No. Ferrisburgh	1.50	.4	.3	.1	5	0	3	--	--	--	1	--	2	--	--	--	--	--	--	--	--	2	--	--	--	--	--
49	“ “	“ “	1.70	.1	.1	.0	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50	F. L. Davis	Woodstock	1.30	5.5	4.	1.5	230	7	10	--	5	5	5	--	13	2	1	10	--	--	171	2	--	14	3	--	--	7	--
51	J. R. Kennerson	Peacham	1.60	1.	.7	.3	30	0	4	--	--	--	5	--	13	--	--	--	--	--	11	1	--	--	--	--	--	--	--
52	Edward Gordon	Burlington	--	.7	.2	.5	4	7	3	--	--	1	2	--	--	--	--	--	1	--	--	--	--	--	--	--	--	4	3
53	E. Hitchcock	Rutland	1.75	2.	1.7	.3	43	6	7	--	1	--	1	--	2	--	--	--	1	1	25	--	--	12	--	--	1	--	5
54	“ “	“	2.00	.5	.4	.1	2	5	2	--	--	--	--	--	--	--	--	--	--	--	1	1	--	--	--	--	3	--	2
55	F. W. Spaulding	Poultney	2.25	.3	.3	.0	1	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	1
56	J. B. Gorham	Putney	1.58	4.5	2.75	1.25	210	0	4	--	--	--	2	--	--	--	--	--	8	--	170	--	--	26	4	--	--	--	--
57	“ “	“	1.50	.3	.29	.01	8	1	3	--	--	--	1	--	6	--	--	--	--	--	--	--	--	--	1	--	1	--	--
58	“ “	“	--	1.25	.5	.75	17	6	4	--	--	--	2	--	--	--	--	--	--	--	11	--	--	3	1	--	4	2	--
59	D. H. Morse	Randolph	1.65	.25	.25	.0	3	0	1	--	2	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--
60	“ “	“	1.65	.45	.4	.05	8	0	3	--	--	--	--	--	--	--	--	--	1	--	6	--	--	1	--	--	--	--	--
61	“ “	“	1.75	.3	.3	.0	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
62	M. W. Clark	Burlington	1.35	1.	.7	.3	8	3	3	--	--	--	4	--	2	2	--	--	--	--	--	--	--	--	--	--	--	3	--
63	Alpha Messer	Rochester	2.00	9.	.4	.1	307	21	9	--	--	15	6	8	1	10	--	--	--	--	241	2	--	14	10	--	8	13	--
64	“ “	“	2.25	.2	.2	.0	0	4	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4	--
65	“ “	“	2.25	.1	.09	.0	0	2	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--
66	“ “	“	2.50	.1	.09	.2	2	2	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--
67	D. K. Hall	Rutland	1.75	.3	.2	.1	6	0	1	--	--	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--
68	“ “	“	1.60	.2	.2	.0	2	0	1	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
69	“ “	“	1.70	.4	.3	.1	8	1	5	--	--	--	3	--	--	1	--	--	1	--	2	1	--	--	--	--	1	--	--
70	“ “	“	1.45	.6	.4	.2	8	4	3	--	--	--	--	--	--	1	--	--	--	--	2	--	--	5	--	--	4	--	--
71	“ “	“	1.40	1.	.7	.3	20	5	7	1	--	--	1	--	6	--	--	--	4	--	5	--	--	2	1	--	--	5	--
72	“ “	“	1.35	1.5	1.2	.3	20	3	6	1	--	--	1	--	1	5	--	--	2	--	10	--	--	--	--	--	--	3	--
73	E. S. Brigham	St. Albans	1.50	.4	.3	.1	11	2	5	--	--	--	5	--	2	--	--	--	2	--	1	--	--	1	--	--	--	2	--

TABLE II. IMPURITIES IN TIMOTHY SEED—*Continued*

Sample number	Sent by	Where bought	Price per bushel in dollars	Percent of total impurities	Per cent of inert matter	Percent of foreign seeds	Number noxious foreign seeds in two grams.	Number useful foreign seeds in two grams.	Number of kinds of weed seeds in two grams	Detailed statement of kind and number of of foreign seeds in 2 grams: Noxious foreign seeds.																Useful foreign seeds			
										Red-root	May-weed	Green foxtail	Pigweed	Charlock	Pepper-grass	Evening primrose	Hair-grass	Common plaintain	Red-stem plantain	Purslane	Five finger	Sheep sorrel	Curled dock	Yellow daisy	Vervain	Red top	Alsike clover	White clover	Red clover
74	" "	"	1.85	.2	.2	1.0	1	0	1	--	--	--	--	--	--	--	--	--	1	--	---	--	--	--	--	--	--	--	--
75	H. C. Bruce	Sharon	1.65	2.	.8	1.2	29	33	8	3	--	--	1	1	2	--	--	--	2	--	10	4	--	6	--	--	--	33	--
76	" "	"	1.65	1.8	.7	.1	50	5	4	--	--	--	--	--	--	--	--	--	11	--	21	--	--	15	3	--	--	5	--
77	C. B. Kendall	Troy, N. Y.	1.40	2.4	1.8	2.6	51	1	5	--	--	--	--	--	2	--	--	--	2	--	35	--	--	11	1	--	--	--	1
78	Waite & Stokes	Rutland	1.50	3.4	1.	.4	40	0	5	--	--	--	6	--	--	--	--	--	5	--	22	--	--	4	3	--	--	--	--
79	" "	Burlington	1.65	.9	.89	.01	4	1	1	--	--	--	--	--	4	--	--	--	--	--	---	--	--	--	--	--	--	--	1
80	F. B. Pier	Brattleboro	1.35	.4	.3	.1	8	5	3	1	--	--	--	--	6	--	--	--	1	--	---	--	--	--	--	--	4	1	--
81	L. M. Cragin	Springfield	1.60	1.5	1.2	.3	31	1	5	--	--	--	6	--	3	4	--	--	4	--	14	--	--	--	--	--	--	1	--
82	J. O. Sanford	Stamford	1.80	1.2	.8	.4	23	1	5	--	--	--	4	--	13	2	--	--	1	--	2	--	--	--	--	--	1	--	--
83	" "	"	1.50	.9	.4	.5	24	4	4	--	--	--	7	--	--	4	--	--	--	--	9	3	--	1	--	--	4	--	--
84	E. O. Lee	Buffalo, N. Y.	2.20	.2	.2	.0	1	1	1	--	--	--	--	--	--	--	--	--	1	--	---	--	--	--	--	--	--	1	--
85	" "	Brattleboro	1.90	3 5	.1	3.4	1	47	1	--	--	--	--	--	--	--	--	--	1	--	---	--	--	--	--	--	47	--	--

TABLE III. FOREIGN SEEDS FOUND IN TIMOTHY, SUMMARZIED BY KINDS

Latin Name	English Name	Percent of samples in which it occurred	Maximum number found in 5 grams	Equalling the following number in 1 lb.	Average number in 5 grams	Equalling the following number in 1 lb.
Noxious foreign seeds						
Amarantus sp	Red root	5	3	270	1	90
Anthemis Cotula	May weed	3	5	450	2	180
Chætochloa viridis	Green foxtail	5	15	1,350	5	450
Chenopodium album	Pigweed	42	14	1,260	3	270
Brassica Sinapistrum	Charlock	2	8	720	4	360
Lepidium Virginicum	Pepper-grass	37	20	1,800	4	360
Oenothera biennis	Evening primrose	21	13	1,170	4	360
Panicum capillare	Hair grass	7	7	630	8	720
Plantago major	Common plantain	4	10	900	4	360
Plantago Rugellii	Red-stem plantain	38	15	1,350	3	270
Portulaca oleracea	Purslane	4	5	450	2	180
Potentilla sp*	Five finger	42	241	21,690	31	2,790
Rumex acetosella	Sheep sorrel	20	20	1,800	3	270
Rumex crispus	Curled dock	2	1	90	1	90
Rudbeckia hirta	Yellow daisy	43	26	2,340	5	450
Verbena hastata	Vervain	21	10	900	2	180
Useful foreign seeds						
Agrostis alba	Red top	1	1	90	1	90
Trifolium hybridum	Alsike clover	30	47	4,230	4	360
Trifolium repens	White clover	50	33	3,070	5	450
Trifolium pratense	Red clover	8	5	450	2	180

* Apparently most if not all of this was Potentilla Monspeliensis.

ERRATA. In heading of columns 4 and 6, for 5 grams read 2 grams. In columns 5 and 7, multiply numbers by 2½.

TABLE IV. FOREIGN SEEDS FOUND WITH RED CLOVER SUMMARIZED BY KINDS

Latin Name	English Name	Percent of sampling in which it occurred	Maximum number found in 5 grams	Equalling the following number in 1 lb.	Average number in 5 grams	Equalling the following number in 1 lb.
Noxious foreign seeds						
Alsine media	Chickweed	5	1	90	1	90
Amarantus sp	Red root	40	20	1,800	3	270
Ambrosia artimisiaefolia	Roman wormwood	4	1	90	1	90
Anthemis cotula	Mayweed	12	5	450	2	180
Brassica Sinapistrum	Charlock	17	15	1,350	6	540
Brunella vulgaris	Self-heal	1	1	90	1	90
Chætochloa glauca	Yellow foxtail	19	8	720	2	180
Chætochloa viridis	Green foxtail	81	112	10,080	20	1,800
Chenopdium album	Pigweed	51	84	7,560	14	1,260
Cnicus arvense	Canada thistle	1	1	90	1	90
Chrysan. leucanthemum	White daisy	1	1	90	1	90
Euphorbia maculata	Spotted spurge	.1	1	90	1	90
Euphorbia Preslii	Spurge	6	4	360	2	180
Lepidium Virginicum	Pepper-grass	1	1	90	1	90
Panicum capillare	Hair-grass	37	9	810	3	270
Panicum Crusgalli	Barnyard-grass	17	1	90	1	90
Panicum glabrum	Small crab-grass	31	10	900	2	180
Panicum sanguinale	Crab-grass	28	6	540	1	90
Paspalum sp		48	16	1,410	4	360
Plantago aristata	Bracted plantain	43	7	630	2	180
Plantago lanceolata	English plantain	59	31	2,790	4	360
Plantago major	Common plantain	5	6	540	3	270
Plantago Rugellii	Red-stem plantain	77	182	16,380	20	1,800
Polygonum Persicaria	Smartweed	60	20	1,800	7	630
Rumex acetosella	Sheep sorrel	58	41	3,690	7	630
Rumex crispus	Curled dock	57	22	1,980	4	360
Sisymbrium officinale	Hedge mustard	1	1	90	1	90
Thlaspi arvense	Penny cress	4	1	90	1	90
Verbena hastata	Vervain	5	1	90	1	90
Useful foreign seeds						
Chætochloa Italica	German millet	1	......	90	1	90
Medicago sativa	Alfalfa	37	42	3,780	8	720
Panicum miliaceum	Millet	1	1	90	1	90
Phleum pratense	Timothy	79	540	48,600	63	5,670
Trifolium hybridum	Alsike clover	31	29	261	4	360
Trifolium repens	White clover	31	8	72	7	630
Grass, not determined		17	6	54	2	180
Seeds, not determined		28	8	72	3	270

TABLE V. A COMPARISON OF THE CONDITIONS OF RED CLOVER AND TIMOTHY SEED

		Total percent of impurities	Percent of inert matter	Percent of viable seed	Number of weed seeds in 1 lb.	Number of useful seeds in 1 lb.	Approximate number of seeds in 1 lb.
Red Clover	Maximum	14.	11.1	13.6	21,240	48,600	
	Minimum	0.0	0.0	0.0	0.0	0.0	
	Average	3.4	.65	2.7	5,940	7,920	336,000
Timothy	Maximum	9	5	3.5	69,382	10.622	
	Minimum	0.1	0.0	0.0	0.0	0.0	
	Average	1.1	0.7	0.3	9,040	8,475	1,175,200

DISCUSSION OF THE RESULTS

1. Timothy seed.—The standard of purity of timothy seed which is recommended by the United States department of agriculture is 98 per cent. This standard has no legal status, but is simply an expression of expert opinion as to what should be the purity of good commercial seed. A comparison of the results of our examinations with this standard shows that in general the timothy samples were of excellent purity. Only nine samples out of the eighty-five fell below this standard, that is, contained more than 2 per cent of impurities. These were numbers 20, 29, 34, 50, 56, 63, 77, 78, 85. Each of four other samples, numbers 23, 40, 53 and 75, were just up to the purity standard; in other words 5 per cent were just at standard, and only 10 per cent were below standard. It is evident, therefore, that the bulk of the timothy seed sold in Vermont, assuming that our samples are fairly representative, is comparatively clean. It would appear then that there is plenty of fairly clean timothy seed on the market. The next question is, can the buyer depend upon getting clean seed if he wishes it? The evidence so far as presented in our returns lead to the conclusion that he can, and that it is largely a matter of price; that is to say, if the buyer is willing to pay a higher price he can get clean seed, and that the foul seed is sold at a low price. Thus the average price of the 85 percent of the samples which were above the standard in purity was $1.70 a bushel, whereas the average price of the other 15 percent, those samples which were at or below standard, was $1.60. In numerous cases the same man sent two or more samples of different price. An examination of the table shows that this occurred in the case of five out of the nine samples which were below standard. A comparison of these five with the five higher price samples sent by the same men is instructive. In each case the two samples upon the same line in the following table came from the same man.

COMPARISON OF TIMOTHY SEEDS OF DIFFERENT PRICE FROM THE SAME SOURCE

Cheaper seed				Higher price seed			
Sample No.	Price	Purity	No. weed seeds	Sample No.	Price	Purity	No. weed seeds
29	$1.75	97.5%	55	30	$2.00	99.5%	5
34	1.60	93.5%	123	35	1.75	99.4%	15
63	2.00	91.0%	307	64	2.25	99.8%	0
78	1.50	96.6%	40	79	1.65	99.1%	4
85	1.90	96.5%	1	84	2.20	99.8%	1
Averages,	$1.75	95.0%	105		$1.97	99.5%	5

The moral seems evident. The cheaper seed contained ten times the amount of total impurity and over twenty times as many weed seeds as did the higher price seed. Moreover, the higher price seed had larger and brighter kernels, and it would without doubt germinate considerably better and produce stronger plants. In consideration of all these facts it becomes evident that the same amount of money invested in the higher price seed would bring more value in seeds than would a like investment in cheap goods, and that in addition practically no weed seeds would be introduced with the high-price goods.

Comparative examination of the price and purity of these seeds shows, however, that it is the relative and not the actual price which must be taken as a criterion. Thus, sample 63 which was ths foulest seed examined cost a high price, $2.00 a bushel, but a comparison with 64 and 65, the other samples from the same place, shows that it was the cheapest seed from that source. It would seem, therefore, that if one is dealing with a good and reliable seedsman, and is willing to pay for the cleanest seed obtainable he may expect to get seeds of a good degree of purity. Comparisons often show, however, that purity and price are not properly related (compare 82 and 83, 56 and 57, 34 and 36). Such examples indicate that critical examination of the seed is after all the only certain course. The experiment station will make such examination on request.

The preceding discussion has been based on the total impurity found in the samples. The nature of the weed seeds which occur is also a matter of importance. Yellow daisy, pigweed, plantains, pepper-grass, five-finger and evening primrose are found most commonly. Sample 63 contained the astounding number of 54,225 seeds of five-finger (*Potentilla monspeliensis* ?) to the pound. About 40% of the samples contained seeds of plantain, and the yellow daisy was found in 43% of them. Most Vermont farmers will agree that they have already enough of these weeds without such extensive additional seedings.

2. Red clover seed.—The standard of purity recommended by the Department of agriculture for red clover seed is 98 percent. Only 29 of the 74 samples examined were up to this standard, 45 fell below it; in other words, 61 per cent were below the purity standard, and only 39 per cent above it.

Two of the clover samples (Nos. 2 and 48) contain weed seeds at the rate respectively of 19,500 and 21,200 to the pound, while eighteen of those samples showing greatest impurities average to contain 13,000 weed seeds to the pound. Of the seeds represented above, green foxtail, pigweed, red-stem plantain (*P. Rugellii*), smartweed, English plantain, sheep sorrel and curled dock are of the most common occurrence. Of these the plantain and sheep sorrel are the most injurious to the farmer. A pound of sample No. 49 would contain over 16,000 seeds of red-stem plantain, while the same amount of No. 54 would yield nearly 3,000 seeds of the English plantain, a pernicious weed which is fast gaining a foothold on many of the Vermont farms. It should be noted that several samples contain seeds of the penny-cress, a plant of the mustard family, which is the curse of the grain fields of the northwest, but is as yet almost unknown in Vermont.

As stated above, 61 percent of the samples examined fell below the purity standard recommended by the department of agriculture, and only 39 per cent exceeded this standard. The average amount of impurity of the former class was a little over five percent and that of the latter was a little less than 0.8 percent. The average price quoted on the samples of fouler seeds was 9.8 cents a pound, while that on those which were up to the purity standard was 10.2 cents.

Analysis of these figures shows at once that an average increase of four percent in price brought five percent more clover seed. In other words the purchasers of the higher grade seeds secured on the average more clover seed for the same money, and in addition avoided the weed seeds which occurred in the cheaper and fouler seeds.

The question arises at once, was price alone a safe guide to purity? The low price seeds were in general the dirtier, but it does not necessarily follow that all of the higher price seeds are of a correspondingly higher grade of purity.[1] In nineteen cases, two samples were sent by the same person from the same market with price quoted. Comparing these we find that there was not a constant relation between price and purity. Thus, in each of six of these cases, samples were sent having the same price, the comparison follows:

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[1] A pertinent illustration of the fact that relative price is not a guarantee of relative purity has just come to hand. It is a sample of red clover seed sent by Mr. Jas. F. Dow of Waterbury Center, with the statement that it cost 12 cents a pound, and that it was bought for the highest grade seed. An examination gives the following results: Total impurity 19.3 per cent; inert matter, 4.4 per cent; foreign seeds, 14.9 per cent. Noxious seeds: yellow foxtail, 298; pigweed, 51; paspalum sp. 43; sheep sorrel, 25; red-stem plantain, 25; smartweed, 14; curled dock, 12; bracted plantain, 10; black mustard, 8; parsley sp. 8; small crab grass, 7; charlock, 6; english plantain, 5; green foxtail, 4; grass sp. 4; five finger, 1; red-root, 1; hair grass, 1. Useful seeds: timothy, 146; alsike clover, 6; alfalfa, 6. There are 503 seeds of bad weeds in this sample, representatives of 18 different species. A pound of this clover would contain 59,310 foreign seeds.

The two samples on the same line are in each case from the same source.

VARIATION IN PURITY IN CLOVER SEEDS OF SAME PRICE FROM SAME SOURCE

	Cleaner seeds		Dirtier seeds	
Price	Sample	Purity	Sample	Impurity
10 cts.	25	97 8%	26	92.6%
10 "	46	97.9 "	44	97.1 "
10 "	56	99.3 "	57	94.6 "
10 "	59	99.5 "	58	98.8 "
10 "	62	99.4 "	63	97.1 "
10 "	68	98.4 "	67	95.6 "
	Averages,	98.7%		95.9%

From these figures it is evident that there may be a wide variation in the seed offered in the same market at the same price. If so, price alone is not a safe index to purity. This same fact is clearly shown in the further comparison of the remaining thirteen pairs of samples, where the two in each pair were from the same source but were of different price. The two samples on the same line of the following table are in each case from the same source. In each such pair the percentage of purity of the dirtier samples is in italics.

COMPARISON OF CLOVER SEEDS OF DIFFERENT PRICE FROM SAME SOURCE

Cheaper seed			Higher price seed		
Sample	Price	Purity	Sample	Price	Purity
4	8.5	*97.5%*	5	9	98.0%
7	8.5	96.7	8	12	*93.4*
11	9.0	*94.*	12	10	99.4
23	9.5	99.9	24	10	*99.7*
29	10.5	97.3	28	11	*96.4*
31	7.5	*93.8*	32	10.5	99.1
34	9.	*88.4*	33	10	*92.0*
37	9.	96.	35	10	*92.5*
43	9.	*95.3*	45	10	97.6
49	10.	*92.*	47	15	99.5
50	9.5	*98.3*	51	11	99.5
54	11.	97.3	55	12	*94.4*
62	10	99.4	61	11	*89.1*
Averages,	9.0 cts.	95.8%		10.9 cts.	96.2%

It will be seen from the last table that although there was on the, average a difference of nearly two cents a pound in the price, there was very little difference in average purity, and that in six cases out of the thirteen, the higher price seed was the less pure.

To sum up the results from all these figures, it seems, therefore, that if one buys a low price clover seed, he is almost certain to get a dirty article, and that on the average he will purchase more seed for the same money by buying higher price goods. High price, however, does not necessarily mean pure seed, and therefore the purchaser must discriminatingly select his goods from among those of higher price. This requires critical examination under a magnifying glass, and most farmers are not provided with such a glass, or, if they are, they do not feel competent to use it. In this case they must either be satisfied to buy of a reliable dealer, depending upon his judgment and honesty, or they must submit samples to an expert for examination. A considerable number were sent to the experiment station last year, and the station is always ready to make such examinations and report results.

The only really satisfactory outcome will be when seedsmen furnish a definite statement of the percentage of pure and germinable seed in each lot offered for sale. This is entirely practicable, at least for such seeds as the grasses and clovers which are handled in large quantities.

A SOFT ROT OF CARROT AND OTHER VEGETABLES

Caused by *Bacillus carotovorus*, Jones[1]

Since much of this article is of interest only to the bacteriologist, and for purposes of reference, the following summary has been prepared. It is so paged that it will serve also as an index.

SUMMARY

I. OCCURRENCE AND CHARACTER OF THE DISEASE.—A rapid soft rot of carrots caused by a bacillus (*B. carotovorus*). General resemblance of disease to Heinz's white rot of hyacinth and to Potter's white rot of turnip, but organism not the same as either.—Pages 302-304.

II. PATHOGENESIS.—Disorganization of tissues apparently due to an enzym which softens middle lamellae. Wound infections led to decay in roots of carrot, parsnip, turnip, radish, salsify, bulb and leaf of onion, leaf and scape of hyacinth, cabbage head, fruits of tomato, pepper, egg-plant. No decay resulted in young carrot or parsnip plants, or in ripe fruits of orange, banana, apple, pear, or in cauliflower head, Irish potato, beet root, tomato stem and petiole. No infection occurred where the epidermis was not broken. Character of decay in all cases similar: rapid softening of tissues, rate increasing with rise of temperature and abundance of water; exudation of liquid clouded with bacteria; no discoloration except browning of some carrots; disagreeable odors from cruciferous plants and onion, little odor from other plants. —Pages 304-312.

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[1] Most of the study of this organism was made by the writer in the laboratory of plant pathology of the Division of vegetable physiology and pathology in the Department of agriculture at Washington. We are indebted to all of the officers of this division for many privileges extended and courtesies shown, and especially so to Dr. Erwin F. Smith who gave valuable advice and assistance in the details of the investigations.

The original publication of this species is expected to appear in Centrallblatt für Bakteriologie u. Parasitenkunde, 2te Abt. The proof of this article has not reached us at the time the present manuscript leaves our hands, therefore we cannot make the citation more exact.

III. MORPHOLOGICAL CHARACTERS OF ORGANISM.

1. *Form.*—A bacillus; single in older cultures, chains or long filaments in young liquid cultures.—Page 312.

2. *Size.*—Individual rods in young cultures, 0.7-0.8 × 1.5-5 microns; shorter and slightly narrower in old ones. Filaments 10-200 microns long. —Page 313.

3. *Grouping.*—Chains, filaments, small zoögloea masses; little or no pellicle.—Page 313.

4. *Staining.*—Rather slow with aniline colors; Loeffler's methylene blue stains well; stains by Gram's method.—Page 313.

5. *Capsule.*—None observed.—Page 313.

6. *Flagella, motility.*—Motion vibratory, oscillating or darting in young liquid cultures, lost with age. Two to five peripheral flagella.—Pages 313-314.

7. *Spores.*—None demonstrated.—Page 314.

8. *Involution forms.*—Somewhat swollen, vacuolated rods occasionally seen.—Page 314.

IV. PHYSIOLOGICAL CHARACTERS OF THE ORGANISM.

A. CULTURAL CHARACTERS

1. *Nutrient broth.*—Clouding quick, moderate amount, uniform, persistent; little or no pellicle or ring; deposit gray-white, moderate.—Pages 314-315.

2. *Gelatin.*—Rapid surface liquefaction, slower in depths of stab; copious white deposit; slight pellicle formation. Buried colonies globose. Surface colonies white, circular; magnified × 125, ciliate-fringed at margin on second or third day.—Pages 315-316.

3. *Agar.*—Buried colonies, × 125, white, oblong or spindle-form, margins irregular. Surface colonies, second day, round, elevated, smooth, gray-white, wet-shining; magnified × 10 by transmitted light, slightly fluorescent and having transient flaky surface areolations; × 125, margins sharply defined, entire or nearly so. In stab cultures slow growth along depths of stab. Slant cultures resemble surface colonies, showing thin

gray-white growth. No growth into agar; no discoloration. Crystals in old plate cultures.—Pages 316–318.

Carbohydrate agars.—Five percent additions of various carbohydrates inhibited earlier growth. Grape-sugar practically prevented all growth; milk-sugar gave slow but persistent growth; cane-sugar and glycerine gave greatly increased growth after the first week.—Pages 317–318.

4. *Milk.*—Acid formed; coagulation on fourth day; separation of whey; cheese-curd odor; no color.—Page 318.

5. *Blood-serum.*—No liquefaction; growth much like agar.—Page 319.

6. *Egg-albumen.*—No liquefaction; growth much like agar.—Page 319.

7. *Uschinsky's solution.*—Good growth; persistent clouding; fragile pellicle; copious white deposit.—Page 319.

8. *Dunham's peptone solution.*—Feeble persistent clouding; no pellicle; slight deposit.—Page 319.

9. *Cooked vegetables,* partially immersed in water.—

Carrot: Persistent clouding; thin white growth over exposed vegetable tissue; moderate amount of deposit and of gas; little or no pellicle; tissue softened; not discolored.

Potato: Deposit and surface growth on vegetable more copious than on carrot; slight softening and graying of potato; otherwise like carrot.

Various other vegetables gave similar results.—Pages 321–322.

B. BIOCHEMICAL RELATIONS

1. *Temperature relations.*—Optimum 27°–30° C. Maximum for growth 38° C. Death occurred in broth tubes heated 10 minutes at 51° C. Growth much retarded below 12° C.; no growth on vegetable media below 4° C., or on any medium at 1°.—Pages 322–323.

2. *Relation to free oxygen.*—Facultative anaerobe. Slight growth in favorable media in partial vacuum, in oxygen-free atmosphere (Buchner's method), in hydrogen and in carbon dioxide.—Pages 323–325.

3. *Production of acids and alkalies.*—Considerable acid produced in the presence of various carbohydrates, grape sugar especially favoring this. Litmus milk promptly reddened; rosolic-acid peptone bleached, color returning after three months; acid-fuchsin peptone slowly faded. Acids partly volatile, partly non-volatile. In 2 percent sugar-broth cultures acid development may destroy the organism. Slow alkali-production accompanied growth, and in the absence of carbohydrates medium became increasingly alkaline.—Pages 327–328.

4. *Relation of acids and alkalies to growth.*—Best growth in broth neutral to phenolpthalein; growth occurred in broth + 4,0 percent (malic acid) and —4.0 per cent, none in broth +6.0 per cent, doubtful growth on agar —8.0 per cent.—Page 328.

5. *Reduction processes.*—Litmus milk (coagulum) bleached from bottom upward. Methylene-blue-peptone solution not bleached, but bleached upon addition of 1 percent grape sugar. Nitrates in broth culture reduced to nitrites.—Pages 319, 320, 326.

6. *Indol.*—Moderate production in Dunham's solution, and in sugar-free broth.—Page 326.

7. *Hydrogen sulphide.*—Slight development from cultures in broth, on cooked potato and cooked turnip.—Pages 326–327.

8. *Odor.*—Little from most media; offensive from cruciferous plants and onions.—Page 326.

9. *Desiccation.*—Drying for even a short time (2 minutes or less) at laboratory temperature was fatal.—Pages 328–329.

10. *Insolation.*—Ten minutes exposure of agar plates to direct sunlight was fatal, likewise two hours to diffused light. Ten seconds appreciably checked growth. Temperature 35°C.—Page 328.

11. *Gas-production.*—Moderate. With 2 percent broths, milk-sugar in fermentation tubes gave 15 per cent, cane-sugar 10 percent, mannit 8 per cent, grape-sugar 5 per cent, glycerine none. In all cases 20 percent of this gas was carbon-dioxide, 80 percent explosive.—Pages 329–330.

12. *Pigment-formation.*—None. Growth was of a white or delicate cream-white color upon all media.

V. REMEDIAL MEASURES.—Pages 330–332.

1. *Rotation of crops.*—Avoid susceptible plants for several years.

2. *Manuring.*—Avoid use of contaminated compost or manures for susceptible crops.

3. *Desiccation.*—Allow root surfaces to dry thoroughly before storage.

4. *Insolation.*—Allow harvested roots to lie as long as practicable, exposed to sunlight.

5. *Temperature.*—Hold storage room continuously at as low a temperature as practicable without freezing.

I. OCCURRENCE AND CHARACTERS OF THE DISEASE

In December, 1898, Mr. S. S. Chandler of Hardwick, Vt., advised the experiment station that he had suffered serious loss from rotting of his carrot crop for two successive seasons. Specimens of the diseased roots were sent, and examination of these indicated that the rot was of bacterial origin. Further investigations have shown that this was the case and that the organism causing this rot is capable of similar destruction of numerous other vegetables.

Mr. Chandler's experience was as follows: In 1897 he grew carrots on a field which had not been planted to this crop for many years, at least, and probably never before. Commercial fertilizers were used that year.

At harvest time he found occasional roots decayed. The roots were stored as usual in a cellar, whereupon the rot progressed rapidly. He had planned to keep the roots for feeding to his horses during the winter, but this threatening decay forced him to feed them out to other stock as quickly as possible. A portion of the manure produced by the stock so fed, was used upon the field where carrots were planted in 1898. He was is doubt as to the cause of this rot in 1897 and suspected that the roots might have been frosted.

His experience the second year, 1898, was similar to that of the first. There was a small amount of rotting observed in the field, and very serious decay began soon after storage of the roots. He was again forced to feed them out as rapidly as he could and, judging from the conditions in the few that he sorted out and attempted to, keep he would have lost every root if held until late winter. Mr. Chandler now suspected some specific disease and sent samples to the experiment station for examination.

In all cases these roots showed a rapidly progressing soft rot which had apparently begun either at the crown or at the root tip, and progressed most rapidly through the core. Upon cutting open such a root, the decayed portion was found to be softened and usually somewhat browned in color. There was a pretty sharp line of demarkation between the decayed and the sound tissues. Upon microsopical examination, the decaying tissues were found to be free from fungus invasion but to be swarming with bacteria. Such examinations and the making of poured plates showed that the recently decayed tissues contained practically pure cultures of a single organism. Sound carrot roots inoculated with this organism rapidly decayed and in such decaying tissues the original organism was again found to be present in nearly or quite pure cultures. It was considered certain, therefore, that the rot was due to a specific bacterium and a detailed study of this organism was undertaken.

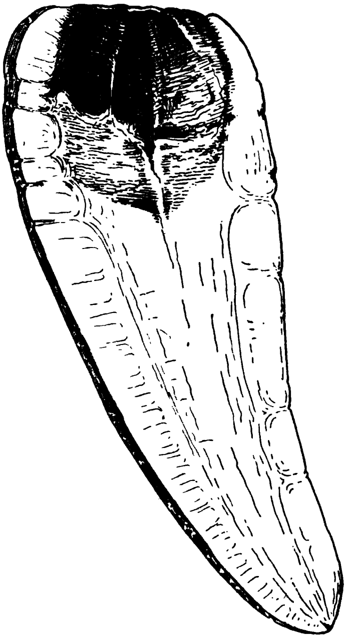

Figure 1. CARROT ROT five days after inoculation at the crown. Shaded portion brown and much softened. Deeply shaded places above were irregular cavities resulting from exudation and evaporation of liquid and collapse of tissues.

There has been little opportunity for field observations in connection with this study and we are not able to say how general this or similar soft rots of carrots may be. Mr. Orton of Fairfax formerly grew considerable quantities of carrots and he tells us that while as a rule carrots have not rotted with him, yet he has at times had trouble with a soft rot which attacked the roots in the field, and did great damage there and later in the cellar. This would be serious for a year or two and then would not be noticed for sometime, when it would again occur. His description of the appearance and behavior of the rot agrees essentially with the characters of the disease under consideration.

It is well known that carrots are liable to decay badly at times in storage. Our observations have been too limited to justify the generalization that this particular organism is the cause of such carrot decays in all cases. We are, indeed, inclined to the opinion that other organisms may be found capable of doing similar injury to this root. Our results taken together with Mr. Chandler's experience do show, however, that this organism is capable of causing serious loss to the carrot grower, and indicate the wisdom of certain preventive measures where this form of rot occurs.

II. PATHOGENESIS OF THE ORGANISM

1. PATHOLOGICAL HISTOLOGY

Microscopic examination of decaying carrot tissues has shown that the organism invades the intercellular spaces and multiplies there with enormous rapidity. The middle lamellæ of the adjacent cells appears to be softened or destroyed by the excretions of the bacteria, since isolation of the cells in invaded tissue occurs much as when woody tissue is macerated in Schultze's solution. The protoplasm in such isolated cells is collapsed but the bacteria have not been observed within the interior of the cells of recently disorganized tissues. This breaking down of the intercellular substance is probably due to an enzym of the nature of cytase excreted by the bacteria and similar to that demonstrated by Potter in the case of his turnip rot organism.[1] Our own studies of this fermentive action have not as yet reached the point that justifies positive statements, however.

2. PATHOLOGICAL RELATIONS TO VARIOUS PLANTS

It has already been stated that inoculations of a pure culture of the organism into mature carrot roots have always caused the rapid decay of the root and that, in such decaying tissue, the organism has been found in nearly or quite pure culture. Similar tests have shown that it is capable of inducing decay in a considerable number and variety of vegetables and other plants under favorable conditions. The following were found to be thus susceptible and some of them proved to be nearly or quite as much so as the carrot root:—roots of turnip, ruta-baga, radish, salsify, parsnip, bulbs of onions, leaf-stalk of celery, leaves and scapes of hyacinth, fruits of tomato, egg-plant and pepper. Less rapid or less complete decay followed its inoculation into leaves and stems of stored cabbages and cut lettuce. There was no decay resulting from inoculations into the following:—ripe California naval orange, ripe banana, ripe apples (Golden Russet and Rambo), ripe pear (Winter Nellis), cauliflower, Irish potato,[1] sweet potato, beet and asparagus. Repeated inoculations, under varying and most favorable circumstances, were made into Irish potato tubers, but in no case was there any decay or other evidence of invasion by the organism. Slices of uncooked potato and also of beet and of sweet potato were placed in sterile petri dishes and inoculated, but in no case did growth of the organism or decay follow.[1]

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[1] Potter M. C., On a Bacterial Disease—White Rot—of the Turnip. Proc. Univ. ot Durham Phil. Soc., Nov., 1899.

Seedling plants of carrot and parsnip were grown in pots and these were inoculated when about four weeks old, both in leaves and roots. In no case did decay or other evidence of bacterial invasion follow in these young plants. Inoculations into the leaves and stems of young (half-grown) lettuce plants and into the petioles and stems of tomato plants likewise gave negative results.

3. DETAILED METHODS OF INOCULATIONS

Most of these inoculations were made in winter (February to April). In such the roots and fruits were obtained fresh from the market and fresh sound specimens were selected. The method of inoculation generally practiced with roots (carrot, beet, turnip, salsify, radish) was to wash them in distilled water, then immerse for from ten to thirty minutes in a 0.1 percent solution of mercuric chloride to free them from surface organisms. Experience showed that this latter precaution was unnecessary, however, and some of the later inoculations were made into washed but unsterilized roots.

In the earlier inoculations with fruits (apple, pear, banana, tomato, egg-plant and also with onion bulbs) a small area on the surface was rendered sterile by pressing a hot knife blade upon it for a moment, the subsequent inoculation being made by needle prick or scalpel thrust at the center of this area. This method was considered open to the objection that it killed the surface cells and in all cases except egg-plant, where such inoculations led to decay, subsequent inoculations were made without such injury to the surface. In all these reinoculations, the results were similar to the earlier ones, that is the decay was induced.

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[1] Just as this manuscript is leaving our hands, we find that decay has resulted from inoculations into slices of sterile, uncooked potato in a petri dish. Since numerous trials, made previously by the same method, have failed, we conclude that the tuber used at this time was peculiarly susceptible.

In the leafy plants (lettuce, cabbage, celery, hyacinth,) the only precaution was to select clean specimens and to rinse the plants thoroughly in distilled water. In these cases there was, of course, greater possibility of the introduction of surface germs along with the organism inoculated. As a partial check upon this method, therefore, other wounds were made with a sterile scalpel or needle and of the same extent as those made in the corresponding inoculations and these wounds were moistened by a drop of sterile water. In this way surface germs were given quite as favorable opportunity for entrance as at the point of inoculation, but in no such case was there any decay or other evidence of bacterial invasion.

The inoculations were made by transferring a two or three millimeter loop of broth, or other liquid culture, to the surface of those plants not disinfected, and stabbing through this a short distance into the underlying tissues with a flamed needle, or opening a slit in the surface with a sterile scalpel and introducing a loop of the culture into this wound. In case of roots which had been disinfected by immersion in corrosive sublimate, a surface layer of tissue was frequently removed from a small area (about 5 mm. in diameter) by means of a sterile knife and the inoculation was made into the center of this freshly exposed tissue. In all cases, therefore, the inoculations amounted to wound infections.

Several trials were made by simply placing drops of the fluid culture upon the uninjured surface of susceptible plants (celery and carrot) but in no case did infection result. These observations indicate that the organism cannot ordinarily make its way through the uninjured cuticle.

In the case of hyacinths and celery, however, where a decaying leaf lay in a moist chamber in immediate contact with a healthy leaf, the decay quickly invaded the latter.

Sterile slices of uncooked vegetables afforded opportunity for more exact observations than did the entire roots and were much employed in these studies. They were prepared by washing and peeling the vegetable (potato, carrot root, etc.) rinsing this through several distilled waters and then either flaming the surface or immersing from ten to thirty minutes in 0.1 percent solution of mercuric chloride. In the earlier work, the roots were then washed and precautions were taken to remove the surface layers which might contain corrosive sublimate, cutting slices from the core only. Later it was found that by properly drying the roots so that no solution flowed over the cut surface, the slices could be used without such precautions. In all cases slices 1 cm. or less in thickness were cut from the disinfected vegetable, with precautions against air contaminations, and these slices placed in sterile petri dishes. These were usually incubated 24 hours at 35°–37° C. to test their sterility, before use for inoculations.

These petri dishes after inoculation were in all cases held at laboratory temperatures (20°–25° C.) The same was true of the roots and other vegetables unless otherwise stated.

The whole roots were loosely placed in an uncovered jar in most cases. In some of the later experiments, placing them in covered dishes so as to lessen evaporation, was found to hasten the earlier stages of the invasion, but did not otherwise alter the results. The fruits, leafy plants, and bulbs, except those of growing plants, were in most cases kept in a partially closed vessel at laboratory temperature (20°–25° C.) or in a chamber connected with a refrigerator (moist atmosphere, temperature 15°–20° C.) In some cases they were simply wrapped in paper as will be explained in discussing the results

4. DETAILED RESULTS OF INOCULATIONS

Carrot roots.—Detailed observations and records were made during the earlier studies upon some twenty whole roots inoculated at several different times, uninoculated checks being held in all cases. In every case the characteristic decay has promptly followed inoculation and no decay has occurred in any check. At least as many more roots have since been inoculated with like results. Both long orange and half-long varieties have been included.

The first evidence of invasion following the inoculation into carrot root, was a water soaked appearance of the tissues immediately about the wound. This was apparent in from 18 to 36 hours, temperature 20°–24°C. During the next day or two there was evidence of the breaking down of the tissues at the point of inoculation, often accompanied by the exudation of drops of light gray liquid, swarming with the bacillus. If the roots were exposed to the dry air of the laboratory the breaking down of the cellular structure and the evaporation of this liquid usually led to the formation within the root of an irregular and gradually enlarging cavity bordered by the more recently decayed tissues, see figure 1. When in from one to two weeks, the roots were cut open for examination, it was found that the decay had involved from one-fourth to the whole of the inte-

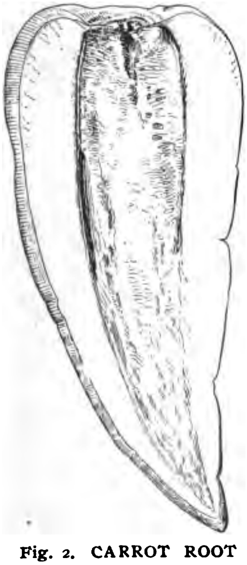

Fig. 2. CARROT ROOT Ten days after inoculation at the crown. The decay was confined to the core owing to the drier condition of the outer tissues. Compare with figure 1.

rior of roots kept at 20°-24°C. Poured plates were made from several of these roots, and in all such cases the original organism was found in nearly or quite pure cultures. The decay usually proceeded at a uniform rate through the different tissues of the root. Where there was any difference it was associated with varying water content, the organism invading the moisture tissues more rapidly, see figure 2.

Inoculations were made upon hundreds of slices of sterile uncooked carrot in petri dishes. (See methods, page 306.) In every case they were rapidly rotted. When a 2 mm. oese of broth or similar culture was placed on the surface of such a slice, there resulted a water soaked appearance of the underlying tissues in from 6 to 12 hours at 20° to 23°C. In 24 hours this area enlarged to a diameter of from 1 to 2 cm. Frequently at this stage water, drawn from the interior of the root, formed a large drop on the center of the decaying spot. Such drops were milky with bacterial growth and were, doubtless, drawn to the surface by the osmotic action of the products of such growth. Frequently where no such drop was formed there was a delicate moist gray bacterial film over the invaded surface. The surface growth was never conspicuous, however, and in many cases was not apparent.

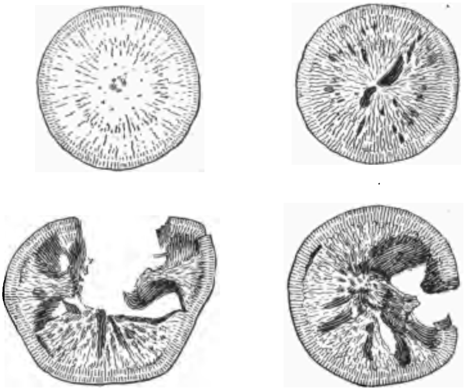

Fig. 3. CARROT CULTURES

Showing appearance of uncooked slices of the root in a petri dish culture six days old. The left upper piece was not inoculated; the others were. The drawings indicate the discoloration and disorganization which resulted.

The invaded areas were rapidly softened, and as a result of this, together with the loss of water cracks opened through them, as shown in figure 3.

The tissues of half-long orange roots usually turned brown or nearly black (sepia), as a result of the invasion of the organism, this discoloration beginning within twenty-four hours. In long orange roots, on the contrary, there was no discoloration, or it was but slight and slower in appearing. It was suspected at first that this difference in discoloration of these roots was due to difference in their tannin content. In order to see if this explanation was correct, roots of each of these two varieties were obtained from several sources, extracts of these were made separately by macerating 5 grams of the fresh root in 100 cc. of water and allowing to stand in the refrigerator 24 hours. This extract was then tested for tannin but practically none was found in any case. Tests with solutions of gum guac showed, however, a marked difference in the amount of oxydyzing enzyms[1] or oxydases present, the half-long orange roots containing much more of the enzym than did the long orange varieties. There was, however, evidence of the presence of oxydase in the long orange roots in sufficient quantity to produce a slow discoloration if there was an oxydizable substance to act upon. Since no such discoloration appeared as a rule, even on long standing, it was concluded that the difference in discoloration was due to the presence, in the half-long varieties, of this relatively larger content of oxydazes, together with some easily oxidizable chromogen other than tannin.

Parsnip roots.—Several roots were inoculated at different times. In all cases except one, the inoculations were made into moist solid tissue and the decay quickly followed. In one root the inoculation was made into the core at the butt end and it failed. Examination later showed that the core tissues here were dry and pithy and the failure was evidently due to this lack of moisture.

Pieces of uncooked parsnip root in sterile petri dishes, upon inoculation, were invaded and rotted about as rapidly as similar slices of carrot. The invaded tissues were changed to a clay color at first soon deepening into a cinnamon-brown.

Cruciferous roots.—Roots of turnip, ruta baga and radish were inoculated and numerous slices of the uncooked roots were tested in sterile petri dishes as in the case of carrot and parsnip. Under both methods of trial,the organism invaded the tissues even more rapidly than it did those of the carrot or parsnip. In globe turnip at laboratory temperature, the decay involved a circle about the point of inoculation of 1 cm. in diameter at the end of the second day. On the fifth day the entire root was soft and pulpy so that it could not sustain its own weight. Average size table radishes were completely rotted on the third day after inoculation. There was no marked change of color in any of these roots, the invasion being at first indicated by the water soaked appearance of the tissues and, immediately following this, by their softening and disorganization. The decay of these cruciferous plants was accompanied by an offensive odor (mercaptan ?)

Cabbage.—Inoculations made by needle stabs through the thin overlapping leaf-blades at the top of cabbage heads did not induce decay, but prompt invasion followed stab inoculation into the more solid and presumably moister tissues of the stem or fleshy petoiles at the under side of the head. The decay thus started spread pretty rapidly so that the entire head would usually be involved in a week or two at laboratory temperatures (20°-25°C.) The amount of decay occurring in four days is shown in figure 4. It was of course impossible to sterilize the entire cabbage head. Care was taken to have the inoculated surface sterile and the earlier decay was certainly due to the carrot rot organism. In the later stages, other organisms doubtless played some part.

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[1] Much assistance was secured in connection with these tests from Dr. Oscar Loew and Mr. A. F. Woods, to whom I am also indebted for advice regarding other matters.

Cauliflower.—Two inoculations were made into cauliflower stems under favorable conditions for the growth of the organism (moist chamber, temperature 20°-25°C) but no decay resulted.

Celery.—Five bunches of celery were inoculated at different times, the inoculations usually being made into several of the young blanched leaf stalks in each bunch. In some cases the bunch was kept in a moist chamber, in some it was wrapped in paper and placed on a shelf in the laboratory. With one exception every stalk inoculated quickly decayed. In this one case the inoculation was into an outer partly green leaf-stalk where the tissues were quite dry and fibrous. In the case of the plants wrapped in a paper and kept on a shelf in the laboratory, the wrapping was insufficient to keep the outer leaves from wilting, yet the decay advanced through the young blanched leaf-stalk, at the rate of 5 cm. in 24 hours. The rate of decay was even more rapid in the moist chamber where a leaf-stalk 25 cm. long was invaded and rotted in two days. The decaying tissues emitted a peculiar sweetish and unpleasant odor. The rot did not invade the tissues of the stem or "crown" even under the most favorable circumstances and when inoculated freely.

Salsify.—Two roots of this plant decayed when inoculated in the crown but did so less rapidly than did carrot or turnip. The decay advanced faster in the vascular ring than in the adjacent parenchyma.

Onions.—Six mature bulbs were inoculated by pricks or stabs into the outer scales, uninoculated checks being held in each case. In every case decay followed promptly. The advance was about twice as rapid at a temperature of 20°-23°C, as it was in a cool compartment of the refrigerator (16°-20°C.). It was noticeable that while the decay progressed rapidly through the scale lengthwise and around the bulb, it passed more slowly from scale to scale. In one case an inoculated bulb lay in a cool box two months. The outer scales, comprising nine-tenths of the bulk of the bulb, decayed promptly but the decay was so slow in reaching the heart of the bulb that several long healthy sprouts were thrown out. Finally two of these sprouts were inoculated each by a single needle prick. Decay was evident at the point of inoculation in 24 hours, and within a week these shoots were entirely rotted. It is probable, therefore, that their long escape was due to the fact that their uninjured epidermal layers presented an effective barrier to the entrance of the germs. Three young table onions from the market were inoculated and decayed very rapidly, and similarly to the mature bulbs. These decaying onion tissues in all cases emitted an offensive odor.

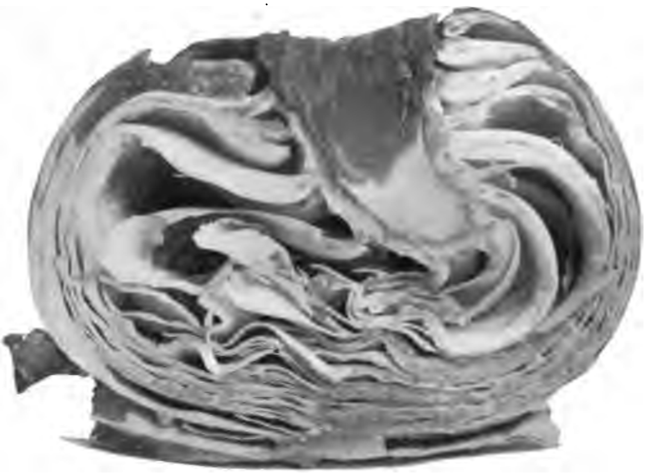

Figure 4. DECAY IN CABBAGE

Showing the extent of the rot on the fourth day after a needle stab inoculation into the base of the stem with a pure broth culture of *Bacillus carotovorus*. Kept in a moist atmosphere, at 20°–22° C. The more darkly colored portions of the stem and of the base of the leaf at the left were entirely softened. Inoculation and photograph made by F. R. Pember. Reduced ×½.

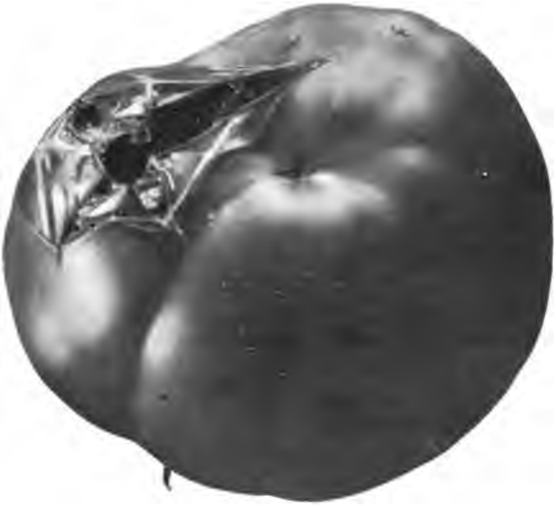

Figure 5. DECAY IN GREEN TOMATO

Fruit clinging to parent plant in the garden in August. Inoculated by needle stab four days previously with a pure broth culture of *Bacillus carotovorus*. Photograph, natural size.

Hyacinth.—The leaves and scapes of potted plants of Dutch hyacinth, in the flowering stage, decayed rapidly where inoculated in the younger and moister tissues near the base. These plants stood uncovered in the laboratory, at 20°–23°C. Similar inoculations into the dryer and older tissues near the summit of the scape or above the middle of leaves, failed to cause serious decay in all cases where the plants remained exposed to the dry air of the laboratory. In these the decay usually started and made slow progress for a day or two, then ceased and the spots dried out. In several cases the same leaves and scapes were later reinoculated near the base and active decay followed. This difference in behavior was attributed to the difference in the water content of these basal tissues since in later trials when the plants were covered with a bell-jar, rapid decay followed inoculation in the upper, less watery, leaf tissues. When the decay was once started it progressed very rapidly, in some cases (in a moist chamber) spreading across the leaf and involving 3 to 5 cm. in length in a single day.

Fruits of tomato, egg-plant and pepper.—All were found to be very susceptible to this organism. Inoculations were made both into green and into ripe fruits of tomato and pepper, and into ripe egg-plant. The results were practically alike in all cases, viz: rapid soft decay, *but progressing more rapidly in the green fruits than in the ripe ones.* Green peppers inoculated and placed in a cool chamber at 18°C. were entirely decayed in eight days. In green tomatoes, under similar circumstances, the decay was quite as rapid. In each case it was considerably less rapid in the ripe fruits inoculated at the same time and kept under similar conditions. Inoculations of tomatoes still on the growing plants in the green-house in April and in the open garden in August, gave similar results, viz: decay of fruit in all cases but more rapid in green than in ripe fruits. The progress of the decay was as follows (green-house plants in April): Hard, green, half-grown fruit inoculated by a single needle prick to a depth of 2 or 3 mm., showed in 24 hours a slight water-soaked appearance about the point of inoculation. On the second day this area was 3-5 mm. in diameter, dark-colored, somewhat sunken, and when on the lower side of the fruit there was slight oozing of gray liquid from the needle puncture. The progress of the decay thereafter was rapid until in from a week to ten days the entire fruit was involved and usually dropped from the stem. In the more rapidly

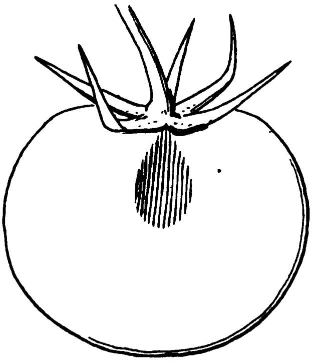
Fig. 6. YOUNG TOMATO

Clinging to parent plant in green-house (April). Shaded area shows the extent of the decay at the surface on the third day after a needle-stab inoculation. Natural size.

growing fruits in the garden, in August, cracks usually opened through the area of decay after three or four days, and the decay was even more rapid than in the green-house, see figure 5. When inoculated green tomatoes were kept in a moist chamber at the laboratory temperature (20°–24°C.) the decay was similar but more rapid. An inoculation into a single egg-plant fruit from the market led to similar decay. It was not possible to try inoculations upon either pepper or egg-plant fruits on growing plants, but the behavior of the growing tomato leads to the opinion that fruits of egg-plant and pepper clinging to the parent plant, would decay in the same way.

Inoculations have been made into carrots, tomatoes and other vegetables, using cultures which had been developed continuously upon agar or in broth for over a year. The decay was prompt, showing that the bacillus does not lose its pathogenic powers by such cultivation.

5. COMPARISON WITH OTHER PATHOGENICALLY SIMILAR ORGANISMS

As will be seen from the preceding results, this bacillus resembles, in its pathogenesis, Heinz's *Bacillus hyacinthi septicus*[1], which causes a soft white rot of the hyacinth and also Potter's *Pseudomonas destructans*[2] which causes a soft white rot of turnip. It differs from Heinz's organism, however, since that does not liquefy gelatin while this one is a rapid liquefier. Potter's organism has a single polar flagellum (*Pseudomonas*) whereas this has several peripherally disposed flagella. It seems probable that further study of the bacteria concerned with the soft rots of plants will swell the list to a considerable number of organisms which resemble the above and each other more or less closely in their physiological characters. Indeed, it would not be strange if such studies reveal a considerable group or number of groups of closely related organisms whose differentation will tax the skill and patience of the bacteriologist as much as has the attempt to exactly define the relationships of members of the *B. coli* group.

III. MORPHOLOGICAL CHARACTERS[3]

1. *Form.*—A bacillus with rounded ends occurring singly or rarely in pairs in old agar and nutrient broth cultures, but frequently in pairs or chains of several cells or in filaments in young cultures (24–48 hours) in nutrient broth and other liquids. In young agar cultures (24–48 hours, temperatures 22°–25° C.) these chains and filaments were better developed and often reached a length of 100 to 200 microns or more.

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[1] Heinz, A. Centrallblatt f. Bakt. u. Parasitenkunde, Bd. V. pp. 535–539, (1889).

[2] See footnote page 304.

[3] Zeiss 2mm oil-immersion lens and compensating oculars 6 to 12 were used in the more exacting of these studies.

2. *Dimensions.*—(*a*) Diameter: Broth culture, 24 hours growth at 22°-25°C, stained in fresh, cold, watery solution of fuchsin, showed extremes 0.6 to 0.9 microns, four-fifths of the rods being between 0.7 and 0.8 microns. Agar culture 24–36 hours, 28°-33° C, stained in fresh, cold, watery solution methyl violet showed 0.6 to 0.8 microns. Old cultures (agar 20 days) were slightly narrower, 0.6–0.7 microns.

(*b*) Length: Broth cultures, 24 hours growth at 22°–25° C, cells 1.5 to 5 microns averaging 2.8 microns; many pairs and some longer chains and filaments. Agar cultures 24-36 hours, 28°–33° C, showed many distinct rods of similar length (1.25 to 4 microns) along with chains and filaments frequently reaching a length of 50 to 100 microns or more. Agar culture 20 days old, rods mostly distinct, 1.5 to 3 microns long. Numerous measurements made of hanging drop preparations and of those stained in other ways did not differ essentially from the above.

3. *Grouping.*—The formation of chains and filaments has been noted above. Zoögloea masses 25 microns or more in diameter occurred frequently in young growth (24 hours) in broth and other liquid cultures.

4. *Staining powers.*[1]—The bacillus takes the watery aniline stains so far as tried but with many of them it stains rather slowly. Good results were secured by from 5 to 10 minutes staining in watery solutions of fuchsin, gentian violet, methyl-violet and methyl-blue; carbol-fuchsin stains quickly and deeply; 5 minutes in Loeffler's aniline methylene blue; gave good stain; the organism is also stained by Gram's method.

5. *Capsule.*—No evidence of any was observed with the above stains.

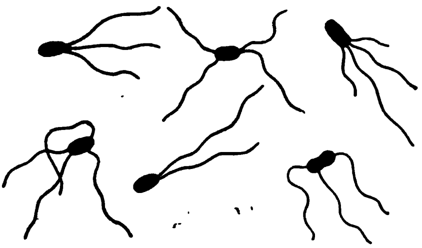

Fig. 7. BACILLUS CAROTOVORUS
Flagella stained by Löwits' method.

6. *Motility and Flagella.*—Active motility occurred in beef broth, vegetable broth and other liquid cultures during the first few days (20°—30° C), but older cultures showed less activity. In freshly invaded carrot tissues, the organisms were very actively motile. The movements of single rods were usually vibratory although in active young cultures direct or darting movements were frequent. Many of the chains or filaments when these occurred showed active vibratory or serpentine movements.

Preparations from young agar (24 hour) cultures were stained by van Ermengem's nitrate of silver method for flagella with rather unsatisfactory results, but excellent stains were secured by Löwits' method with the more actively motile organisms from young carrot broth cultures. These showed each rod to have from two to five peripheral flagella, figures 7 and 8. In the agar cultures the flagella were 6 microns or less in length, but in the carrot broth cultures their length was greater, often 10 microns or more.

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[1] Grübler's stains were used in all cases.

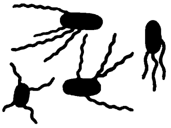
Fig. 8. BACILLUS CARTOVORUS
Flagella, stained by van Ermengam process.

7. *Spores.*—In no case has there been any evidence of spore-formation, although diligent microscopic search has been made in cultures of various ages and upon various media, (agar, gelatin, broth, potato, carrot). Many such cultures have been subjected to the thermal test but exposure to a temperature above 55° C. has killed all of the organisms in every tube tried.

8. *Involution forms.*—Peculiar forms differing from the normal, have been observed in a few cases. In carrot cylinder[1] cultures two months old, a considerable number of the rods have been observed to show refractive oval areas in the interior. The appearance of these suggested spores, but they refused to take spore stains and these cultures were killed by heating 10 minutes at 75° C. (lower temperatures were not tried. These were interpreted therefore as vacuolated rods. Similar vacuoles occupying swollen areas in rods have occasionally been observed in young (1-3 day) agar cultures. In the latter these peculiar rods were often quite actively motile, and exposure to 55° C for ten minutes killed them.

IV. PHYSIOLOGICAL CHARACTERS

1. CULTURAL CHARACTERS ON VARIOUS MEDIA

The culture media used were prepared with much care, following closely the methods of the Procedures recommended for the study of bacteria of the American public health association[2]. Distilled water was always used, and nearly all the chemicals were c. p. The nutrient broths were prepared from lean beef and reactions of media determined by titration with phenolphtalein.[3]

Nutrient broth.—Rapid growth in broths ranging from zero to +1.7 per cent. For example, zero broth, 10 cc. per tube, inoculated with 1 mm. oese, 28°-30°C., perceptibly clouded in five and a half hours.

At laboratory temperatures (22°-30°C.) the liquid becomes semi-opaque from clouding in 24 hours, cloudiness slowly increases for several days, then remains without much change for a long time, tubes three months old being still well clouded. If undisturbed a delicate incomplete pellicle develops, which readily breaks up and settles upon agitation, leaving a faint incomplete ring easily washed away.

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[1] See details of vegetable cylinder cultures later.

[2] Report submitted at the meeting of the Association in Philadelphia, September, 1897.

[3] The reaction of the medium is stated in the percent of n/1 alkali or acid required to render it neutral to phenolphtalein, Acidity is indicated by the + sign, alkalinity by the — sign.

A slight grayish white precipitate appears on the second day and slowly increases until ultimately (three months) it amounts to one per cent of the original volume of the medium. Reactions of cultures in broth originally slightly alkaline to litmus (+1.5 per cent) as determined by neutral litmus paper were as follows:

At end of each 2, 5, 10, and 12 days feebly acid.
At end of each 18 and 25 days feebly alkaline.
At end of 53 days, strongly alkaline.
At end of three months, more strongly alkaline.

Titration of such a broth culture one month old showed the reaction to be —1.0 per cent.

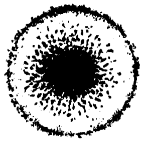

Fig. 9.
GELATIN COLONY
Surface of plate culture, 48 hours old, as seen under magnification x 125, drawing reduced to x 10.

GELATIN.—The organism grows well on gelatin and liquefies it rapidly.

Colonies.—Plate cultures, reactions +2.0 per cent, 20°-21°C., colonies apparent on second day. Viewed under a magnification of 125 diameters the buried colonies were at first spherical, uniformly granular, margins sharply defined. In most cases this sharp outline was soon lost, the body of the colony becoming surrounded by a faint halo of organisms scattered through the surrounding gelatin. This apparance was apparently associated with the early stages of liquefaction of the gelatin. Such colonies then rapidly enlarged in size and soon reached the surface. Those that failed to do so after two or three days showed concentric zones with a radiating fringe-like growth at margins as described later in the surface colonies.

Surface colonies.—Were uniformly granular at first (under Zeiss 16 mm. objective and 8 ocular) but soon so liquefied the gelatin as to form a funnel shape cavity and the collection of the precipitate at the bottom of this formed a gray-white nuclear mass. This was usually dense and opaque at the center surrounded by detached irregular flaky masses as shown in figure 9. The liquefied gelatin surrounding this was uniformly granular and showed a denser rim bordered externally by a fringe of delicate indistinctly radiating fibrils. This fringe is due to bacterial growth radiating from the body of the colony into the surrounding unliquefied gelatin. Its width varied with temperature, but in plates held at 20°-22° C. averaged about 50 microns on the second and third days of growth.

Stab cultures.—Growth developed the full length of the stab, but was more rapid in the upper portion. Liquefaction first appeared at the surface and led to the formation of a broad shallow funnel as shown in figure 10. Liquefaction extended quite across the surface before reaching far into the depths of the tubes, but ultimately the medium was entirely liquefied. No gas bubbles were observed in gelatin. A fragile and imperfect white pellicle was formed in the liquefied tubes and an abundant white precipitate, its volume amounting to two or three times that formed in broth. Liquefied tubes, 41 days old, were strongly alkaline to litmus paper.

Growth upon sugar-gelatins.—Stab cultures were made into tubes containing respectively 5 percent cane-sugar gelatin, 10 percent of cane-sugar gelatin, 5 percent grape-sugar gelatin, 10 per cent grape-sugar gelatin. These were held at temperatures of 16°–22° C, for seven days. There was a slow growth in all of these, with some liquefaction in the cane sugars, but much less rapid than in the plain gelatin. The growth in the grape sugar media was about one-fourth of that in the cane-sugar, and there was no liquefaction.

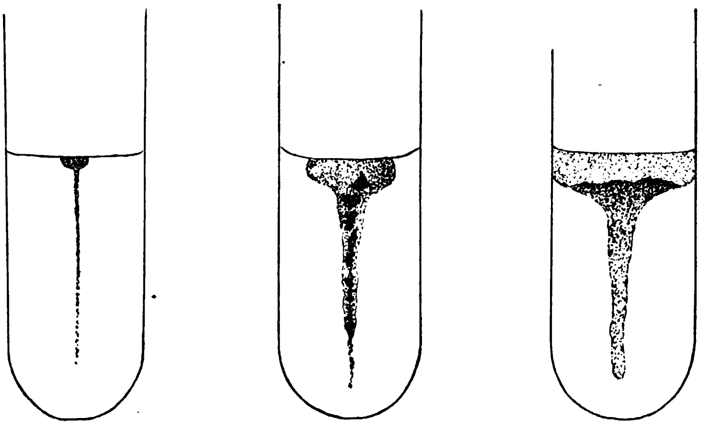

Fig. 10. GELATIN STAB CULTURES

The first, 24 hours at 20 degrees; the second, 48 hours at 20 degrees; the third, 7 days at 15 degrees, equivalent to 3 days at 20 degrees.

AGAR.—Good growth on agar of reaction +1.5 percent. In plate cultures colonies were visible on the second day (30 to 40 hours) at temperatures of 22°–25° C.

Buried colonies under magnification 125 diameters, varied in outline from globose to oblong and spindle shape, with irregular margins.

Surface colonies were gray-white with a slightly elevated, smooth, wet-shining surface. With a good hand lens (magnifying 10-15 diameters), young colonies, 40 to 50 hours old, showed a characteristic appearance, best seen against a dark back-ground. They were at this stage scarcely opaque and had peculiar flaky or areolated surface markings as shown in figure 11. These were transient, usually disappearing within 24 hours, and thereafter the colonies appeared uniformly granular under such magnifications. This flaky appearance of the young colonies has been observed in some other species so that it has not great value as a differential character however. It is doubtless due to the formation of a delicate surface pellicle which is ruptured by the subsequent growth of the colony into the irregular more or less concentrically arranged fragments observed. Under magnification of 125 diameters, this flaky character is not apparent by transmitted light but is so by reflected light. The margins were sharply defined and entire or slightly crenate for the first day or two but usually became indistinct with age.

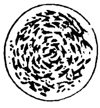
Fig. 11. AGAR COLONY Surface of plate culture, 48 hours growth, x 10.

Agar streaks show good growth within 24 hours, 22°-28° C. Margins sharply defined and entire in earlier growth becoming crenate or irregularly lobed after a day or two, slightly elevated, wet-shining, gray-white, no discoloration of agar or tendency to grow into it. Dense clouding and rather copious deposit in condensation water.

Agar stabs showed slight growth along full depth of stab, but decreasing toward bottom. Growth spread rather slowly over the surface as a slightly elevated, wet-shining layer with crenulate margins which ultimately reached nearly or quite to walls of tube. Gas bubbles were rarely observed in plain agar stabs, but were formed in shaken agar tubes, see p. 318. No lateral outgrowths from the stab into the agar were observed. Agar was not discolored. Crystals were abundant in agar plate cultures four weeks old. (ammonium phosphate?).

Carbohydrate agars.—Cultures were made in agars containing respectively 5 percent additions of the following carbohydrates: cane-sugar, grape-sugar, milk-sugar, mannit, glycerine (reactions +1.5 percent).

In every case the earlier growth was retarded by such addition. With the grape-sugar this retardation was so great that heavy and sometimes repeated inoculation was necessary to get a growth started. In milk-sugar the effect was similar but less pronounced. Thus in a typical series the relative growth at the end of the second day taking the plain agar as the basis of comparison was: plain agar, 100 per cent; cane-sugar agar, 75 per cent; glycerine agar 65 per cent; milk-sugar agar 0; grape-sugar 0. In the same series on the fourth day the growth on the cane-sugar and glycerine agars was equal to that on the plain agar, while on the milk-sugar a few isolated colonies were appearing. At the end of one month the growth on cane and milk-sugars and glycerine much exceeded that on plain agar. That on the glycerine agar formed a thick semi-opaque, creamy-white, wet-shining layer covering the entire surface of the slant. That on the cane-sugar agar was similar but thinner and not fully covering the upper surface of the slant, estimated at 60 per cent of that on glycerine. On milk-sugar agar the character of growth was again similar to glycerine but only the lower half of the slant was covered, amount estimated at 40 per cent of that on glycerine. On the plain agar the growth was not over one-half as thick as the preceding, estimated at 25 per cent of that on the glycerine. There was no growth on the grape-sugar agar in this series, and in other cases where it did get started, it made but feeble growth.

Gas formation in agar.—This was tested with the plain agar, and for agars containing 5 per cent additions of each of the following carbohydrates: cane-sugar, grape-sugar, mannit, glycerine. The method employed was to transfer a 2 mm. loop from a young broth culture to a melted agar tube (40°C) shake thoroughly and allow to stand at room temperature, 23°-28°C. Upon the second day numerous gas bubbles were developed in the plain agar tubes, fewer in the glycerine and mannit, and very few and small ones or none at all in the cane and grape sugars.

Milk.—Ten cc. tubes of fresh milk, amphoteric to neutral litmus paper, $+1.7$ to $+2.0$ percent, inoculated with 1 mm. loops from broth cultures and held at 23°-26° C. showed no visible change for three days. On the third day the milk was distinctly acid and thereafter remained so. On the fourth day curdling occurred. Heavier inoculations (2 mm. loop) led to curdling on the third day, in irregular masses and coarse granules. The curd was rather soft at first but became firmer on long standing. It was smooth and free from gas bubbles, and when fully settled occupied about one-third the depths of the medium. The whey promptly separated from the curd but remained rather turbid even after standing some weeks. The older milk cultures had a distinct and agreeable odor of cheese curd. Upon heating such above the thermal death point of the organism, and tasting, there was a decided cheese-curd flavor, not wholly agreeable, but not bitter. No color was developed at any time.

Fermentation tube cultures of milk gave no gas in the closed end. Upon emptying at the end of two weeks the milk was found to be only partly curdled in the closed end, but upon heating in boiling water the curdling was immediately completed. Inasmuch as other experiments showed the organism to be easily killed by its own acid products, various milk cultures were tested for viability, with the following results: one culture 11 days old alive; one culture 25 days old dead; one culture 35 days old dead; another 35 days old alive, but slow in developing, evidently living organisms very few and feeble; culture 3 months old dead. Distillation of acid milk cultures showed the presence of both volatile and non-volatile acids.

Litmus milk.—(Fresh amphoteric milk plus 5 percent saturated watery solution dry litmus). Distinct reddening within 24-48 hours (20°-24° C.), color slowly deepening to purple. Casein was precipitated as in milk, but somewhat more tardily. Bleaching began in 7 to 10 days and was completed in about three days thereafter. Steaming the bleached tubes to kill the organism was followed by return of red color within a week. In unsteamed tubes this return of color occurred in two or three weeks.

Loeffler's blood serum.—(Calf's blood). Surface streak cultures made good growth, smooth, white, moist, resembling that on agar slants, but no liquefication, and no discoloration of the medium during two months at temperature 22°-25° C.

Egg albumen.—White of egg coagulated and sterilized by heating at 80°-90° C. for two hours on each of three successive days. Growth on slants of this medium in general resembled those on blood serum ; no liquification, no staining of substratum.

Uschinsky's solution, proved an excellent medium for this organism. Distinct growth appeared in tubes within 24 hours, at 22°-24° C. This consisted of a delicate surface pellicle at first which was very fragile and upon the slightest agitation was precipitated or diffused. There was uniform clouding after the second day although the most active growth continued at the surface with pellicle formation for a month or more followed by a gradual loss of cloudiness in the upper layers. There was a copious white deposit amounting, in cultures a month or more old, to 20 percent of the original volume of the medium, which was fifteen or twenty times the precipitate formed in broth cultures.

The reaction of Uschinsky solution cultures to neutral litmus paper was as follows: sterile medium, faintly acid; well clouded cultures, three, five and twelve days old, all faintly acid, acidity decreasing slightly with age; cultures two months old more strongly acid than was the original medium.

Dunham's peptone solution.—(One percent Witte's peptone, 0.5 percent c. p. sodium chloride). In this but feeble growth was made. Faint, uniform clouding occurred in 24 hours (22°-25° C.), which increased but slowly and never became heavy ; persistent for two months and probably much longer ; no pellicle or ring ; precipitate very slight, estimated at one per cent of that in nutrient broth.

Reactions to neutral litmus paper :—sterile medium faintly alkaline ; cultures four days old showed no change in alkalinity, but older ones (five weeks) showed distinctly stronger alkaline reaction.

Dunham's solution was used as a basis for several other synthetic media as follows :

Methylene-blue peptone.—(Dunham's solution plus two percent of a 0.1 per cent aqueous solution of methylene blue). Growth as in simple Dunham's solution. No reduction of color during three months growth. Upon this medium with the further addition of one percent grape sugar the growth was more vigorous as shown by heavier clouding ; at the end of 24 hours the blue color was reduced to one-third of the original depth and remained so until the third day when it returned. Litmus paper tests on the sixth day showed the medium decidedly acid, on the ninth day the tubes were free from cloudiness and transfers then showed them to be sterile. The organisms were evidently destroyed by their own acid products. Distillation of this acid medium showed the presence of both a volatile (carbon dioxide?) and a non-volatile acid.

Indigo-carmine peptone.—(Dunham's solution plus two percent of a 0.5 percent aqueous solution of indigo-carmine). Medium not used until several days after making; growth as in simple Dunham's solution. Both the inoculated and the uninoculated check tubes continued to bleach until all color was lost and it did not return. Reactions to litmus paper as in Dunham's solution. Where one percent of grape sugar was added to the above medium there was more vigorous growth and development of acidity, followed by the loss of cloudiness and the death of the organism as in the tubes of methylene-blue peptone solution with grape sugar.

Rosolic acid peptone.—(Dunham's solution plus one percent of the following: 0.5 g. rosolic acid, 20 cc. distilled water, 80 cc. absolute alcohol). Since the alkalinity gave this solution a deep salmon color, one drop of double normal hydrochloric acid was added to 20 cc. of the medium, reducing it to a pale salmon color. This color began to fade on the second day after inoculation and entirely disappeared within a few days. The cultures remained colorless for nearly three months, when they slowly became pink-red and this color persisted. These changes showed the slow formation of acid in the earlier stages of the growth neutralized by very slow alkali formation later.

Acid fuchsin peptone.—(Dunham's solution plus two percent of a solution of 10 mg. Grübler's acid fuchsin, after Weigert, in 30 cc. water; added one drop of double normal hydrochloric acid per 20 cc. of medium, reducing color to deep red). During the first month there was the feeble growth characteristic of Dunham's solution cultures, but no change of color; at the end of the second month the color had faded to one-half the depth of the sterile check tubes and the cultures were still slightly acid to neutral litmus paper; at the end of third month the color had faded to one-fourth that of the checks and the reaction to litmus paper was faintly alkaline.

Other synthetic media.—The following additional media were tried:

(*a*) Water 400 cc., dipotassium phosphate 80 mg., ammonium phosphate 40 mg., magnesium sulphate 40 mg., sodium acetate 2 g.

(*b*) Same as (*a*) omitting the sodium acetate.

(*c*) Same as (*a*) substituting sodium formate for sodium acetate.

No growth occurred in (*b*) or (*c*). In (*a*) the characters of growth resembled those in Dunham's solution, but about twice as much deposit was formed. Reaction of sterile medium slightly acid to litmus paper, that of culture slightly alkaline after the sixth day.

COOKED VEGETABLES.—Tubes of various vegetables were prepared by placing in each tube a cylindrical piece of the vegetable cut a little smaller than the tube and about 5 cm. long, the upper half of this piece being slanted to receive the inoculation and the lower half immersed in distilled water. These were cooked and sterilized by steaming on each of three successive days.

Carrot cylinders prepared in this way formed an excellent medium, the chief cultural features were as follows: At 22°–25° C. the liquid was well clouded in 24 hours, and a slight white growth was usually visible on portions of the slant surface; on the second day the clouding so increased as to render the liquid nearly opaque, and there was evidence of slight evolution of gas; growth usually covered much of the surface of the cylinder, smooth, moist, white, thin and not fully hiding the color of the substratum. In older cultures this growth became slightly thicker, but was rarely sufficient to hide the color of the substratum or extended enough to fully cover the surface of the cylinder. Gas formation ceased after three or four days, and other evidences of vigorous growth were lacking after the first week. There was little or no tendency to form pellicle or rim. A white or cream-white precipitate began to form after two or three days, ultimately becoming rather copious. The tissues of the cylinder were rapidly softened so that at the end of a week or less they might collapse if the tube was vigorously shaken. This occurred in some cases within two days. There was little or no discoloration of cylinders. The reaction of the sterile medium is acid to litmus paper. Vigorous cultures three days old showed the liquid still slightly acid, but the tissues of the cylinder alkaline. At the end of one week the liquid also was quite strongly alkaline and more decidedly so at the end of four weeks.

Potato.—The growth characters on cooked potato cylinders were in general similar to those on carrot. The growth on the surface of the cylinder was rather more copious, forming a slightly elevated, smooth, wet-shining, cream-white layer. The precipitate was also a little more copious. There was slight evolution of gas during the first week. The clouding of the liquid was lessened after a week or ten days, but in no case did it entirely disappear. There was a tendency to form zöogloea masses and an imperfect pellicle during the first few days.

Reaction to neutral litmus paper: sterile medium acid; on the second day the liquid was acid, but less so than when sterile, surface growth on cylinder alkaline; third day, liquid slightly alkaline; and this alkalinity increased so that it was decidedly alkaline at the end of four weeks.

A slight graying of the potato cylinder resulted. The cylinders were softened somewhat, but not so completely as were the carrot.

Iodine tests of potato cylinders from old culture tube showed them to be rich in amylo-dextrin, evidently produced by the action of the organism on the starch.

Other vegetables.—Similar slant cylinders in tubes of the following vegetables were used :—common red beet, sugar beet, turnip, ruta baga, radish, sweet potato, onion, asparagus, cocoanut. Good growths appeared in all except the cocoanut, where the development was slight and the tissues were not softened. The general character of growth on these vegetables was similar to that on carrot and potatoes, viz.: quick, heavy clouding of the liquid with delicate white surface growth on the moister portions of the vegetable cylinder, and slight evolution of gas during the first few days of growth.

2. BIOCHEMICAL FEATURES

TEMPERATURE RELATIONS.—*Growth at medium and high temperatures.*—The organism grew well at the usual laboratory temperatures of 20°-25° C., but better at the higher of these. It made a good growth in the thermostat at 33°-34° C., but grew less rapidly at this temperature than at 20°-24° C. The optimum lies between these two and is probably about 27°-30° C., but was not more accurately determined.

There was a slow growth on agar slants and in nutrient broth held at 35°-36.5° C. for six days, but no perceptible growth under these conditions on tubes of steamed potato or of turnip.

There was a very slight clouding of broth tubes held 24 hours in the thermostat at 38°-39° C., but much less than in similar tubes held at 24°C. for the same time. The temperature was then raised above 39°C., and was held for twenty days between 39°-40.5° C. The cloudiness which had appeared in these broth tubes during the 24 hours at the lower temperature, disappeared and the liquid thereafter remained entirely clear, indicating that there was no further growth. At the end of thirteen days, several of the tubes were removed from the thermostat and held at 22°-25° C., but there was no growth. At the end of twenty days the remainder of the tubes were removed to room temperature and held for some time, but no growth was made.

It appears, therefore, that the maximum temperature of growth lies at, or slightly below, 39° C., and that a continued exposure to a temperature slightly above 39° C., is fatal to the organism.

Growth at low temperatures.—The organism made no appreciable growth when held for twenty days at 0.6° to 1° C. upon various media (nutrient broth, Uschinsky's solution, gelatin, potato). In tubes so held, however, growth was prompt when they were removed to temperatures of 20°-24°C., indicating that there is no appreciable injury from such refrigeration.

At 2° C., gelatin tubes showed very slight growth within twenty-four hours, but there was none at the end of four days on various other media tried (broth, agar, steamed potato and turnip).

At 3° C., there was a better growth in gelatin than at 2°, with appreciable liquefaction, and slight growth developed on agar, but none at the end of five days in various other media tried (broth, steamed potato and turnip).

At 4° C., there was perceptible clouding of broth at the end of twenty-four hours, and this slowly increased, but there was no appreciable growth at the end of seven days on any of the following steamed vegetables: potato, carrot, turnip, ruta baga.

At 12° C., there was a slow growth on the above mentioned steamed vegetables, estimated on the fifth day as equalling one-third of the amount made on similar tubes held at 20°-24° C.

Thermal death point.—In these determinations, use was made in all cases of thin tubes of approximately uniform size, 15 × 1.5 cm., and each containing 10 cc. of nutrient broth, reaction +1.7 per cent. The method followed was to transfer to each tube a 1 mm. loop from broth cultures one to six days old. These were allowed to stand for from one-half hour to two hours before heating. The heating was done by immersing such recently inoculated tubes for three-fourths their height in a large kettle of water which was kept constantly stirred by an agitator in the bottom. The temperature was recorded at intervals of thirty seconds throughout the period of immersion and in most cases the extremes of variation during the period of immersion covered less than one tenth of one degree. Under such conditions the thermal death point of the organism was found to be 51° C., in most cases slightly under this. Temperatures as low as 47° had a perceptible retarding effect, however, and all above 49° retarded growth decidedly.

In Uschinsky's solution the thermal death point was found by the above method to be fully one degree higher than in the broth. Uschinsky's solution is slightly acid to litmus paper, whereas the broth was neutral or very slightly alkaline (+1.7 percent), and it is probable that this difference may explain the difference in thermal death point.

Relation to free oxygen.—Cultures in fermentation tubes in both nutrient broth and Uschinsky's solution, show the organism to be a faculative anaerobe. (See later discussion.) This fact is also shown by its growth in gelatin and agar stabs along the full length of the puncture, although in both it makes a better growth near the surface.

Growth in partial vacuum.—Broth tubes recently steamed and inoculated were placed in a sealed chamber from which the air was so exhausted as to sustain a mercury column of but 9 cm. (3½ inches) in height. Growth was much retarded but not wholly checked. At the end of eleven days it was estimated to be one-half as much as in control cultures of the same age which had stood in the normal atmosphere.

Growth in oxygen-free atmosphere.—The organism made a feeble growth in oxygen-free atmosphere as was shown in the following trials. Recently steamed and freshly inoculated tubes of broth and agar were placed in small chambers from which the oxygen was removed by the Buchner method (pyrogallic acid and potassium hydroxide). There was appeciable clouding of the broth at the end of 24 hours, though much less than in normal atmosphere. This cloudiness increased but slightly during five days during which it was under observation. Feeble growth was visible in the agar on the third day and increased slightly during the remaining two days of the experiment.

Growth was estimated at end of five days to be less than one percent of that in normal air.

Growth in hydrogen.—Pure zinc (free from arsenic) and c. p. sulphuric acid were used in the generator, the gas was washed through solutions of silver nitrate and of potassium permanganate and distilled water. Displacement was secured by passing a continuous stream of the gas through the culture chamber (jar) for one hour. The chamber was then hermetically sealed and stood unopened for 13 days.

Upon opening,there was evidence of very slight growth in the nutrient broth, milk (coagulated), agar slant, five percent glycerine agar, five percent cane sugar agar (scarcely perceptible).

There was no perceptible growth in tubes of cooked carrot or cooked potato.

Upon holding in atmosphere at room temperature growth appeared or continued in plain agar, gelatin, nutrient broth, milk, cooked potato; there was no evidence of growth in the others following their removal from the hydrogen.

Growth in carbon-dioxide.—A feeble growth occurred in an atmosphere of carbon-dioxide upon the following media: broth, Dunham's solution, milk, agar, and agars containing five per cent of either cane-sugar, mannit, or glycerine. The organism refused to grow and ultimately perished when confined in carbon-dioxide upon the following media : Five percent grape-sugar agar, Uschinsky's solution, gelatin, sodium acetate medium (see page 320) cooked carrot and cooked potato. These conclusions are based upon three trials of which the detailed records are as follows : c. p. hydrochloric acid was used in the generator and the gas was passed through wash bottles of each one percent caustic potash and distilled water before entering the chamber. In series one and two the displacement of the air by the carbon dioxide was secured by successively exhausting the gas from the chamber(to three inches of mercury)and refilling with carbon dioxide. This was repeated for five successive times, with an interval of from 10 to 30 minutes between each to allow of complete diffusion. In series three the displacement was accomplished by passing a rapid and continuous stream of the gas through the chamber for one hour. The chambers were then allowed to remain hermetically sealed for from 10 to 17 days. In all cases when opened the gas within refused to support combustion.

In series two, two tubes containing methylene-blue (Dunham's sol. + 1 per cent grape sugar + methylene blue) were included as a test of the presence of free oxygen. These tubes were slowly bleached during the first week to a nearly colorless condition and remained so until the chamber was opened. Upon exposure to the air for a few minutes the surface layers resumed their original deep blue color, thus showing clearly the absence of free oxygen in the sealed jar.

After removal of the tubes from the gas chamber they were held for some weeks in the normal atmosphere at laboratory temperatures, 23°–32°C, to determine the viability of the organism.

The results from each of the three series are shown in the following table. The number of tubes of each medium is indicated by the figure in parenthesis.

GROWTH IN CARBON DIOXIDE

	Series 1, in CO_2 10 days		Series 2, in CO_2 13 days, temperature 28°-32° C.		Series 3. in CO_2 17 days, temperature 25°-32° C.	
Medium	Growth in gas chamber	Growth after removal	Growth in gas chamber	Growth after removal	Growth in gas chamber	Growth after removal
Gelatin	-----------	-----------	(2) none	none	none	none
Agar	-----------	-----------	(1) feeble	continued	(1) trifling	continued
5 percent cane-sugar agar	-----------	-----------	(1) feeble	none (?)	(1) very feeble	continued
5 percent grape-sugar agar	-----------	-----------	(1) none	none	-----------	-----------
5 percent mannit agar	-----------	-----------	(1) feeble	feeble (?)	-----------	-----------
5 percent glycerine agar	-----------	-----------	(1) feebler than man'it	continued	(1) very feeble	doubtful
Nutrient broth	(2) feeble	continued	(2) feeble	continued	(1) very feeble (?)	continued
Milk	-----------	-----------	(2) feeble *	continued	(1) growth coagulat'n)	-----------
Uschinsky's solution	(2) none	none	(2) none	none	-----------	-----------
Sodium acetate medium †	-----------	-----------	(2) none	none	-----------	-----------
Cooked carrot	-----------	-----------	-----------	-----------	(2) none	none
Cooked potato	-----------	-----------	-----------	-----------	(1) none	none
Methylene blue ‡ peptone solution	-----------	-----------	(2) feeble	doubtful gr.	-----------	-----------

* This milk showed no coagulation upon removal from the CO_2 chamber, but upon immersing in boiling water it coagulated immediately, showing that there had been growth.

† See p. 320

‡ Dunham's solution plus methylene-blue plus 1 percent grape-sugar, see p. 319. This was inserted partly to serve as a test of the oxygen content of the jar.

Reduction of nitrates to nitrites.—The following medium was used to grow the organism on in order to determine its action on nitrates:

Distilled water	1000 cc.
Witte's peptone	10 grams.
Cudahy's beef extract	2½ "
Potassium nitrate, (c. p.)	3 "

Sodium hydrate to make the reaction + 1.0 percent.

The medium was tested by the starch-iodine method showing the absence of nitrites before it was used. Tests of cultures in this nitrate broth on the fourth day after inoculation showed the presence of an abundance of nitrite, other tests on each the fifth day, the sixteenth day and the twentieth days, gave the same results.

Indol production.—This occurs under favorable circumstances. Two cultures in Dunham's solution (10 cc. each tube) 20 days old and one 22 days old were tested by adding to each 15 drops of a mixture of 2 parts c. p. sulphuric acid in 1 part distilled water. After waiting a few minutes to be sure of the absence of nitrites, added 1 cc. of 1 per cent sodium nitrite solution. No coloration appeared at first, but within five minutes a slowly deepening pink color showed the presence of indol. This color was not so deep as was obtained in the same medium by a culture of *B. coli-communis* which was tested at the same time. The coli culture, was, however, from a strain known to give a very pronounced indol reaction. Similar tests made several times since have given similar results. A second series of tests was made using cultures in moderately alkaline peptonized beef broth, rendered sugar-free by the previous growth in it of *B. coli-communis* for 15 hours. Cultures 22 days old were tested in the manner described above. No color was apparent upon adding the acid, nor did any appear upon the addition of the nitrite. After waiting five minutes the tubes were heated in the water bath at 75-80° C. After a few minutes warming the characteristic color reaction of indol appeared and deepened into a bright pink. This color persisted upon cooling. The depth of the color was estimated at one-seventh of that obtained with the cultures of *B. coli-communis* of the same age.

Development of odor.—There was little odor from cultures upon most media. The only cases where it was sufficiently developed for characterization were in milk cultures (p. 318) which gave a cheesy or curd-like odor; in cruciferous roots (p. 309), both uncooked and cooked, where there was an offensive odor suggesting mercapan; and in onion (p. 310) where the odor was also decidedly offensive.

Production of hydrogen sulphide.—Strips of absorbent paper saturated with a solution of lead acetate were suspended in tubes containing young cultures upon the following media: cooked cylinders of cocoanut, carrot, potato and turnip, Uschinsky's and Dunham's solutions and nutrient broth. These remained for over a week, being several times remoistened. There was slight blackening of the papers, showing evolution of hydrogen sulphide, in some of the potato tubes and in the turnip tubes, and a more pronounced blackening in the broth tubes. Some potato cultures did not blacken the papers, however, and no blackening occurred from the remainder of the media.

Production of acids.—The detailed statements already made of the reactions of cultures upon various media justify the following conclusions:

In the presence of various carbohydrates there is active acid formation usually accompanied by a small amount of gas production. Litmus milk cultures (p. 318) were promptly reddened. In such acid milk cultures the acid was in part volatile and in part non-volatile. The kind of acid was not determined in any case except that in fermentation tubes, twenty percent of the gas formed was carbonic acid.

Numerous comparisons of two percent cane, grape and milk sugar and glycerine in broths showed greatest acid production from the grape-sugar, abuot the same amount from milk and cane and much less from glycerine. The exact data is given later under the discussion of fermentation tube cultures. When there was a considerable amount of the sugar in the medium, the acid production was so great as to destroy the organism. Thus, in Dunham's peptone solution plus one percent of grape-sugar, there was rapid growth, the medium became decidedly acid and death of the cultures resulted within nine days. In Uschinsky's solution, having five percent of cane-sugar, the tube became sterile after forming only one-half as much deposit as was developed in the unmodified solution. The growth must have continued in this case for several weeks, but the exact time of death was not determined. In fermentation tube cultures in two per cent sugar broths, very few living organisms remained in the liquid in the bowl of grape, cane or milk-sugar tubes upon the fifteenth day. Conceiving that this acidity might interfere with the activity of gas production in the fermentation tubes, a series of cultures was made in tubes (including two per cent grape, cane, and milk-sugars, and mannit) where about one gram of calcium carbonate was inserted in each tube. The result was, however, the partial inhibition of growth in the presence of the marble and the production of only about ten percent as much gas. These cultures became acid but less so than similar ones lacking the calcium carbonate.

Alkali production.—This apparently was a constant accompaniment of growth, but in no case was it great. Thus, broth cultures, one month's growth at laboratory temperature, in which the original medium had a reaction of +1.5 per cent to phenolpthalein, gave a reaction of —1.0 per cent. In all cultures where there was continued growth following the exhaustion of carbohydrates or other materials favorable to acid development, the alkalinity slowly increased with age. Examples of this have already been cited under the various culture media. See especially the discussion of rosolic-acid-peptone cultures (p. 320) and of the acid-fuchsn-peptone cultures, (p. 320).

Relation of growth to acids and alkalies.—It has been stated under the discussion of acid production, that the development of the organism may be inhibited and the cultures may ultimately be destroyed by acid-production in media containing sufficient amounts of certain carbohydrates. The relation of growth to the reaction of the medium was more exactly observed, as follows: Cultures in broth which was neutral to phenolpthalein were compared with these rendered alkaline by sodium hydroxide to —2.0 percent and —4.0 percent, and also with others to which malic acid was added to make the reactions +3.0 percent, +6.0 percent, +9.0 percent and +12.0 percent. The neutral broth gave the best growth. The comparative rate of growth, as shown by the relative cloudiness of the tubes upon the second day, 28°-30° C., was estimated as follows: neutral broth=100 per cent; — 2.0 broth=80 percent; —4.0 broth=50 percent; +3.0 broth=10 per cent. There was no growth in broths +6.0, +9.0 or +12.0. Agar tubes were prepared having reactions of —8.0 percent, +6.0 percent, +9.0 percent and +12.0 percent. Slant tubes of these were heavily inoculated and held for four days at 25°-30° C. There was doubtful growth in the alkaline tube, none on any of the acid tubes. These results are noteworthy in comparison with the power of the bacillus to grow and induce decay in green tomatoes, of which the juice shows a reaction to phenolpthalein of +4.0 to +5.0 percent,[1] or even greater acidity according to Dr. Smith's titrations.

Relation to light.—The bacillus is very sensitive to sunlight. Freshly poured agar plates, one-half shaded by closely covering with opaque brown card, were exposed to sunlight at mid-day, early in September. Exposure of ten minutes killed every organism; five minutes exposure killed 87 per cent; three minutes killed 70 percent; one minute killed 33 percent; ten seconds killed 7 per cent. Moreover there was appreciable retardation in the development of those colonies which did appear in the plates receiving even the ten seconds exposure. Longer exposure to diffused light is also fatal. Thus in plates where one-half was covered, above and below and at the circumference, with opaque brown card, exposure for one hour destroyed all organisms for 7 mm. back from the line of exposure, and exposure for one and one-half hours led to nearly or quite complete sterility in the shaded portions of similar plates, diameter 8 cm. The organisms were in all of these cases from twenty-four hour broth cultures. The temperature within the plates during their exposure was 35° C.

Desiccation.—This bacillus has proved remarkably sensitive to desiccation, drying for even a brief period in the atmosphere at laboratory temperatures proving fatal. Thus in one series of experiments a 1 mm. oese was transferred from a broth culture twenty-four hours old to each of several sterile cover glasses. These glasses were then dropped into sterile broth tubes after drying for varying periods of time, temperature 28°–31° C. Exposure for twenty minutes or less, after the last trace of visible moisture left the glass, (thirty minutes after the transference of the loop from the tube,) rendered most of the covers sterile. In a few cases living organisms remained on covers thus dried for several hours, but this was probably due to the formation of a surface film which prevented the desiccation of some of the buried organisms. The experiment was repeated, diluting the broth with sterile water. When drops of this diluted culture were subjected to desiccation, temperature 22° C., some of the covers were found to be sterile after but two minutes drying.

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[1] The acidity of the juice of each of several of the different kinds of vegetables used in inoculation experiments was determined by titration with phenolpthalein. Green tomatoes one-half to two-thirds grown, showed an acidity ranging from +4.0 to +5.0 percent; potatoes were +3.0 to +4.0 percent; carrot roots were +2.8 to +3.6 percent. The baccilus was actively parasitic in all of these.

Behavior in fermentation tubes.—Several series of fermentation tube cultures were made in which sugar-free nutrient broth [1] was the foundation medium. Trial was made of 2 percent additions to this of each grape, cane and milk sugar, mannit and glycerine. Temperature 20°–24° C. In all trials sugar-free tubes were held as checks.

The more important results are summarized in the following table :

TABULAR SUMMARY OF RESULTS IN FERMENTATION TUBES*

Medium Broth with 2% of	Volume of gas in percent of closed branch				Reaction of broth in bulb, 15th day(†)	Composition of gas	
	2 days	3 days	5 days	15 days		Carbon dioxide	Explosive
Grape-sugar	small bubble	3%	4%	5%	+6.4%	20%	80%
Cane-sugar	" "	4%	6%	10%	+6.0%	20%	80%
Milk sugar	0	1%	5%	15%	+5.8%	20%	80%
Mannit	small bubble	4%	6%	8%	acid to litmus	20%	80%
Glycerine	0	0	0	0	+3.0%	20%	80%
Sugar-free broth	0	0	0	0	+1.6%	20%	80%

* *B. coli-communis* was carried through in a duplicate set of fermentation tubes in one of the above series for purposes of comparison. No gas was formed in the cane-sugar tubes and they remained alkaline. In the milk and grape-sugar tubes gas formation began earlier than with the carrot rot and continued more vigorously, so that at seventy-two hours it occupied 25 to 30 percent of the closed end of these tubes. This gas evolution continued but slowly thereafter, amounting on the fifteenth day to 38 percent in the milk-sugar, and 30 percent in the grape-sugar tubes. Titration showed the acidity of the liquid in the bowl to be +5.2 percent in milk-sugar and +5.6 in grape-sugar. The gas composition was about 30 percent soluble in KOH, remainder explosive.

† In one series the liquids in the closed branch were titrated also. The reactions were practically the same as in the corresponding bowls, except in the sugar-free tubes. Three of these were tested and the results, which were very similar in the three, showed an average acidity of +2.6 percent in the closed branch as compared with +1.6 percent in the bowl.

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[1] Broth made from beef, Witte's peptone, reaction +1.5 percent, freed from muscle-sugar by growth in it of *B. coli-communis* for twelve hours, as recommended by Dr. Theobald Smith, Jour. Exp. Med. II, p 556. Pains were taken to secure pure sugars.

In the bulbs.—There was prompt uniform clouding in all except the milk-sugar, where no growth was apparent until the second day. In sugar-free broth the cloudiness was not heavy, and it persisted during the trial (15 days); the glycerine bulb was most densely clouded of any, persistent; in the grape and cane-sugars, the clouding was less dense than in glycerine, and began to clear after the third day; in milk-sugar the clouding was slower than in cane and grape, both in developing and also in beginning to clear. In these three sugars the bowls were clear, or practically so, before the end of the period. No pellicle was formed in any case, and no color developed.

Transfers from the bulbs were made in one series to determine whether the organisms had survived the acidity. There was prompt growth from the sugar-free and glycerine bulbs, slower growth from milk and cane-sugars, and none whatever from the grape-sugar. In another series the results were similar, except from the grape-sugar, where growth resulted, but very tardily indicating that most of the organisms were dead.

In the connecting tube.—No distinct deposit formed in the sugar-free or glycerine tubes. In the others there was a distinct granular deposit which was 2 mm. deep in the milk-sugar tube, and slightly less in the other sugars. The amount of the deposit corresponded in a general way to the amount of gas evolved. The heavier clouding of the bowl extended in all cases to the inner curve of the connecting tube, where it merged into the fainter clouding of the closed branch in the earlier stages of growth. As the growth and gas formation in the closed end began to decline, a sharp line of delimitation was developed at this inner curvature.

In the closed branch.—Faint uniform clouding appeared on the second day in all, although more tardy in milk-sugar and in glycerine than in others. This cleared away after about three days in the sugar-free and the glycerine tubes. The sugar tubes began to clear at the upper end on about the fifth day, but none of them became fully clear during the fifteen days.

Gas formation.—As shown in the table above, this began in grape and cane sugars and mannit on the second day, but was one day tardier in milk sugar. The evolution of gas continued pretty actively in the milk-sugar until about the tenth day, but in the other sugars and mannit there was little evolved after the sixth day.

V. REMEDIAL MEASURES

The studies already detailed show that this organism is capable of developing as a wound-parasite upon a wide range of hosts. Its behavior in cultures in the laboratory indicates, also, that it can live indefinitely as a saprophyte where conditions are favorable. The nature of such a rot precludes the possibility of any specific remedy. The treatment must aim entirely toward prevention. The facts presented in the preceding discussion show clearly the importance of attention to (1) rotation of crops, and (2) manuring. The laboratory studies which are detailed in the following pages, indicate the like importance of (3) thorough drying of the surface of roots, of (4) their exposure to the sunlight before storage and of (5) constant low temperature during storage. By attention to these preventive measures it is probable that the rot can be avoided or practically held in check.

Rotation of crops.—The practical importance of this in the case of serious trouble with any such rot as the one under discussion, is so patent as to require little emphasis. The fact that this organism is capable of attacking such a variety of vegetables, makes such measures peculiarly necessary. Infested soil should be devoted for a period of years to such crops as corn, other grains and grasses. If desired for garden use, the bush fruits could probably be grown safely, or seed crops, such as peas, beans, etc. Among the root-crops beets or possibly potatoes would not be objectionable.

Manuring.—The danger of introducing and perpetuating various injurious germs with compost and manure, is greater than is generally supposed. For example, it has been shown that club-root of cabbage is often brought in with the manure,[1] the same is true of corn smut, and apparently so to a greater or less degree of a considerable number of the fungus and bacterial diseases of garden and field crops. The careful cultivator, therefore, should always aim to guard against this danger. Mr. Chandler's experience, cited on page 303, indicates that the manure pile may be a serious source of soil contamination with this carrot-rot germ. While this is not demonstrated, the evidence is sufficient to show the wisdom of applying manure or compost of doubtful character to crops that are not susceptible to these soft rots, and on the other hand, to use alone for such susceptible vegetables, manure from grain and hay-fed animals, or compost into which garden refuse has not entered.

3. *Drying of root surfaces.*—One of the most striking characters of this organism is its susceptibility to desiccation, as shown by the experiments cited on page 303. Drying under ordinary conditions of the summer atmosphere was almost immediately fatal to the organism. Since the germs must be conveyed to the storage cellar almost exclusively on the surface of the roots, it follows that if these surfaces can be thoroughly air dried before their storage, practically all of the rot-germs will be killed. To secure this they should be left lying on the surface of the ground in the field for some days after pulling, and stored in as dry a place as possible. The efficacy of such treatment is increased by the fact that the organism cannot invade dry tissues. The prompt drying out of the surface wounds which are made in harvesting and trimming the crop will contribute largely

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[1] See discussion Vt. Exp. Sta. Bul. 66, p. 7 (1898).

to their disinfection. As shown in the following paragraph, this treatment will be made still more effective if the drying is accompanied by exposure to sunlight.

4. *Exposure to sunlight.*—Laboratory experiments along this line are reported on page 328. These show that exposure of the organism for ten minutes to direct sunlight, and for two hours to diffused light was fatal. This fact, coupled with its extreme sensitiveness to desiccation, indicate that the best practical means of disinfecting the surfaces of suspected roots is to thoroughly expose them to dry air and sunlight.

5. *Temperature in storage.*—The practical importance of cool storage is recognized by everyone. The growth of this organism decreases from an optimum temperature of about 77°-83° F. (25°-28° C.) to the zero point. Growth is quite slow, however, below 50° F. (10° C.) and is practically checked below 39° F. (4° C.). These temperatures are practicable for any good storage cellar, and coupled with the disinfection of the root-surfaces by drying and sunlight, should prevent serious danger from the rot.

REPORT OF THE HORTICULTURIST

By F. A. Waugh

Two lines of work have chiefly occupied the horticultural department of the station during the year, (1) the study of orchard fruits suited to Vermont, and (2) the study of plums. Those experiments and investigations which are deemed worthy of report at this time are grouped in the following pages under these heads :

Propagation of plums—Preliminary report.
  I. The problem presented.
  II. The teachings of experience.
  III. Results of nursery experiments.
  IV. Later notes.

Further work in plum pollination.
  I. Studies of pollen.
  II. Malformation of blossoms.
  III. Transportation of pollen.

The pollination of apples.
  I. Self sterility.
  II. Other considerations.

The Myrobalan plums.
  I. Historical notes.
  II. Present status.
  III. Variety notes.

Plum tree canker.

PROPAGATION OF PLUMS—PRELIMINARY REPORT

I. THE PROBLEM PRESENTED

The named varieties of plums are always propagated either by grafting or budding. There are great numbers of these budded varieties, very different from one another in external characters and cultural requirements, so that a method of propagation or a stock suited to one may be totally unsuited to another. A large number of very diverse kinds of stocks have been used, also; some of them adapted to one kind of plum and some to another. The extent of these diversities will appear better from the following considerations.

The cultivated varieties of plums show certain general differences sufficiently marked to enable the pomologist to divide them into several *groups*. Each one of these types is so well marked that at some time it has been called a species by some botanist. The different distinct *groups* of this sort of which named varieties are propagated in North America are as follows : Domestica, Damson, Myrobalan, Japanese, Simon or Apricot plum, Americana, Nigra, Miner, Wayland, Wildgoose, Chicasaw, Sand plum, Beach plum, Pacific plum and the western Sand cherry[1]—fifteen in number, besides many hybrids.

The different sorts of stocks which have been used for plums in America are, so far as the writer's knowledge goes, the following : Horse plum, (Domestica), St. Julien, (also Domestica) Myrobalan, Marianna, Japanese, Americana, Nigra, Wayland, Chicasaw, Sand plum, western Sand cherry, Choke cherry, Black cherry (*Prunus serotina*), peach and apricot,—fifteen in all.

If each one of these fifteen different groups of plums was to be tested on each of these fifteen sorts of stocks, as they might reasonably be, there would be 225 different combinations. The propagation of plums indeed has complications.

Yet these complications have not yet been fully presented. Consider that each one of these 225 combinations may be made either by budding or by grafting, and you have 450 different cases to examine. Consider that one stock is suited to one soil and another stock to another, with each one of these soil adaptations to be determined ; consider that certain stocks thrive in certain climates and fail in others ; consider that the multitudinous varieties in the several groups named have not always the same preferences ; consider that sundry practical exigencies in the nursery are often important factors in the selection of stocks ; and you begin to get a view of the difficulties involved in determining what are the best methods of propagating plums.

Fortunately or unfortunately, the data now available will not enable us to go into many of the intricacies here suggested. A great many of the combinations mentioned above have never been tried, and there is nothing to say for or against them. Those which have been tested, so far as known to the writer, are shown in the following tabulation :

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[1] The western Sand cherry, *Prunus pumila besseyi*, may be called either a plum or a cherry. It is usually handled with the plums by plum growers, hybridized with plums by hybridizers, and propagated on or under plums ; so that it is almost necessary to deal with it in this article.

TABLE SHOWING KNOWN COMBINATIONS OF PLUM STOCKS AND CIONS

The asterisk shows that the corresponding combination has been made

For plum groups (cions) read down; for stocks read to the right	Horse plum	St. Julien	Myrobalan	Marianna	Japanese	Americana	Nigra	Wayland	Chicasaw	Sand plum	Sand cherry	Choke cherry	Black cherry	Peach	Apricot
Domestica	*	*	*	*		*	*	*			*			*	*
Damson	*	*	*	*											
Myrobalan			*	*										*	
Japanese	*		*	*	*	*		*	*				*	*	*
Simon	*		*	*										*	
Americana	*		*	*		*	*	*	*		*			*	
Nigra			*	*		*	*	*	*		*	?		*	
Miner			*	*		*		*	*					*	
Wayland			*	*		*		*	*					*	
Wildgoose			*	*		*		*	*	?				*	
Chicasaw			*	*		*		*	*	?			*	*	
Sand plum			*	*					*					*	
Beach plum				*				*						*	
Pacific plum			?												
Sand cherry			*	*			*							*	

II. THE TEACHINGS OF EXPERIENCE

Before taking up a detailed discussion of experiments, it will be best to give a brief summary of present knowledge of plum stocks and their combinations with different kinds of cions. It will be most convenient to discuss this from the standpoint of stocks.

Horse plum, or Domestica stock.—The Horse plum is a variety of the Domestica group, inferior in fruit, but sturdy, and uniform in growth. It has been much used as a stock for Domesticas and Damsons, and is at the present time, regarded by many good nurserymen as the best practicable stock for plums of these groups.

Besides the Horse plum, the miscellaneous seedlings of all sorts of Domesticas have been used for propagation; but their excessive variations in strength and habit of growth are against them.

St. Julien.—This is another form of the Domestica plum, dwarfish, hardy and uniform of growth. It has been extensively tested for Domesticas and Damsons; but is too slow growing for American nursery purposes.

Myrobalan.—The Myrobalan plum is still extensively used for propagating in this country, great numbers of stocks and considerable quantities of the seed being imported from Europe every year. It has been most used for Domesticas, Damsons, Japanese and the many native American varieties. It seems suited to all, or nearly all, of these. It is, however, not perfectly hardy in the northern states and Canada, and this fact has put a limit to its usefulness. It is easily worked and a large percentage of grafts or buds set on Myrobalan stocks "take." It has some tendency to dwarf the varieties worked on it, especially those of strong habit. This means that strong-growing varieties usually overgrow; and overgrowing is often a defect. On the whole, the use of the Myrobalan stock in this country is probably on the decrease.

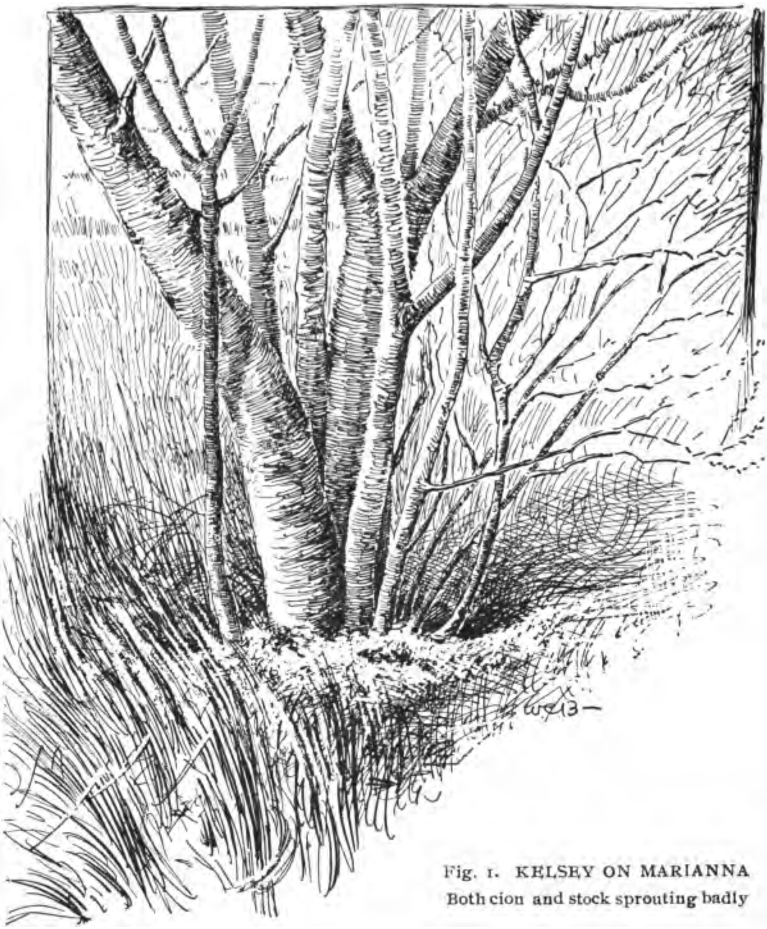


Fig. 1. KELSEY ON MARIANNA
Both cion and stock sprouting badly

Marianna.—This is an offshoot of the Myrobalan plum, but commercially distinct, largely from the circumstance that it propagates very readily from cuttings. It has been very extensively used in this country for propagating all sorts of plums, but more especially in the south for Japanese, Hortulanas, Chicasaws and Wayland sorts. It has most of the advantages of the Myrobalan, being suited to nearly all classes of plums. It has, however, the same defects as the Myrobalan, except perhaps that it is not quite so readily overgrown, and effort is being made by some nurseryman to find a substitute for both Marianna and Myrobalan.

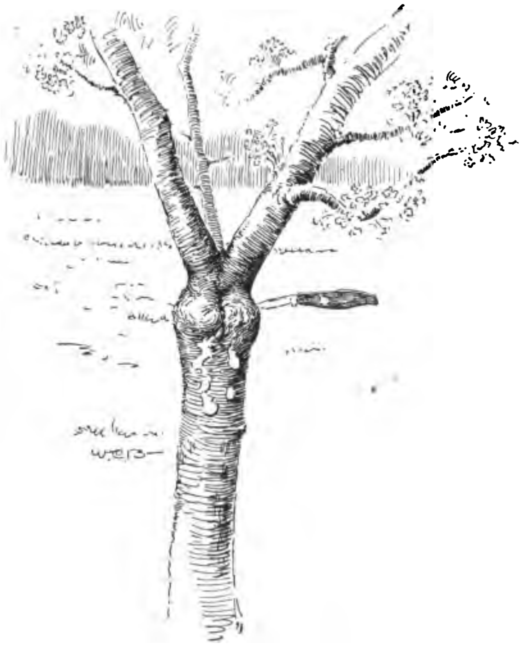


Fig. 2. NIMON ON MARIANNA

A good union

Japanese.—Many horticulturists have felt that Japanese plums would be the best stocks for Japanese plums. Very small opportunity has offered, however, for making the test. The writer has heard of several small experiments, without decisive results. If Japanese plum stocks of any sort could be readily grown from cuttings, like the Marianna, it would be a long step toward their adoption in general nursery propagation. In a few instances this has been done, but never on a commercial scale. There is every reason to believe that Japanese stocks will prove useful for Japanese plums, once there is found a way to grow the stocks cheaply; but it is fairly doubtful whether or not they will ever be useful for other classes of plums.

Americana.—The use of the native Americana plums as stocks has grown up in the northwestern states, and has been based on the demand for something hardier than the stocks in common use. Americana seedlings are now grown in considerable quantities, and are used largely in a commercial way. They have proved well adapted to varieties of the Americana, Nigra, and Miner groups; and have been freely used with apparently good results for other groups. Domesticas, however, seem to unite poorly with this stock.

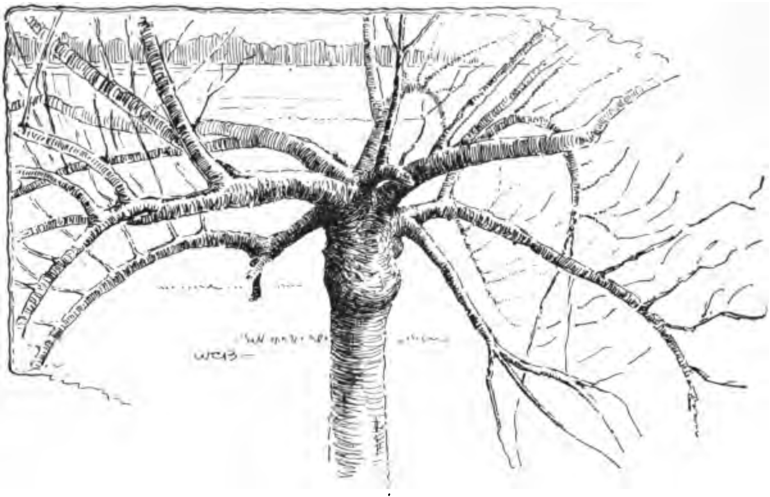


Fig. 3. WESTERN SAND CHERRY ON MARIANNA
A fairly good union

Nigra.—In general the seedlings of Nigra varieties are grown indiscriminately with Americanas, so that separate observations are not available. For the most part the two kinds may be expected to behave alike. Domesticas and the eastern Sand cherry (*Prunus pumila*) have been tried on this stock at the Central experimental farm of Canada, with unfavorable results. A fairly good union resulted between the Domestica cion and the Nigra stock, but the cion overgrew strongly and finally died. The Sand cherry made a poor union.

Wayland.—Mr. J. W. Kerr, of Denton, Md., who hardly needs to be described as an experienced and experimenting propagator of plums, has for several years practiced top-grafting all sorts of native plums on Golden Beauty (Wayland group) branches. He has had the best results. He has also grown seedlings of such varieties as Golden Beauty, Wayland and Moreman, and has root grafted on them. The results have been encouraging.

Chicasaw.—In some of the southern states the Chicasaw plums have occasioanlly been used as stocks, particularly for varieties of the Chicasaw and Hortulana groups. This stock has sometimes been recommended as being adapted to low, wet grounds in the southern states, but it is doubtful if this point is of much consequence. The one serious defect of the stock is its inveterate habit of sprouting, so that where one plants a plum on a Chicasaw stock he presently has a thicket of Chicasaws.

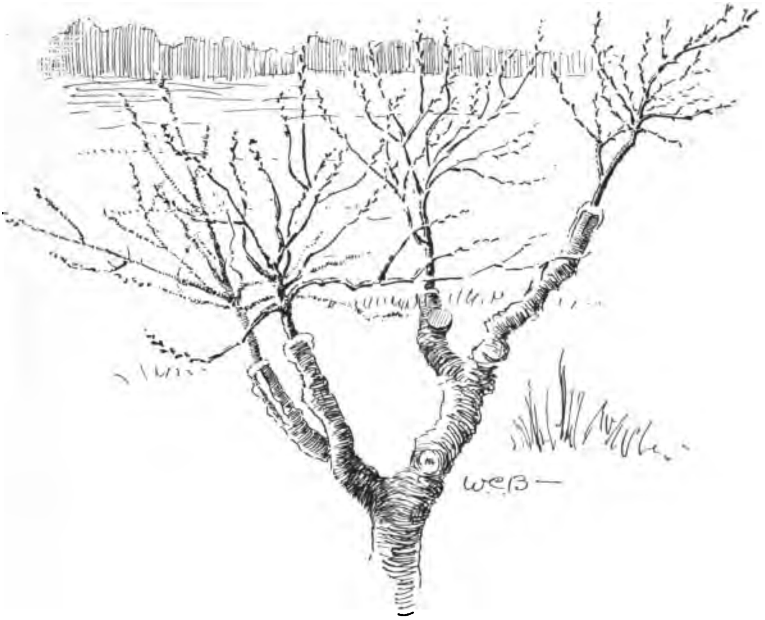
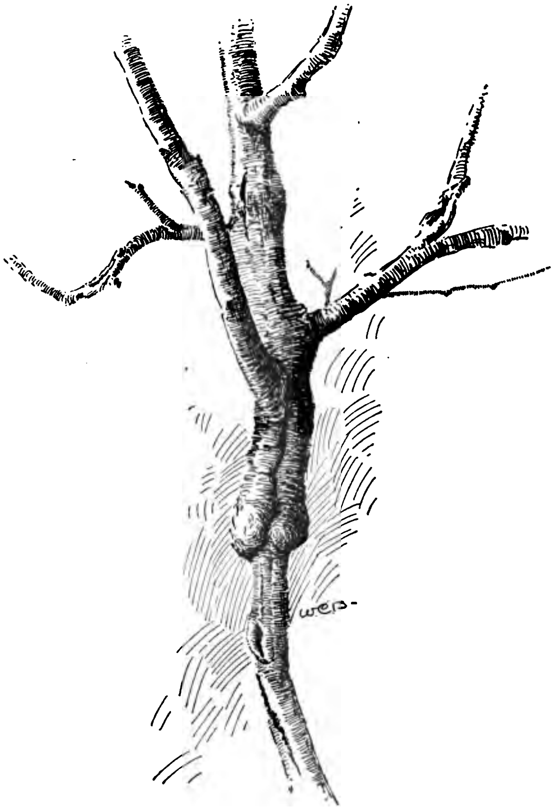


Fig. 4. **SAND CHERRY ON MARIANNA**

A fine "catch" and a first rate union

Sand plum.—This dwarf western plum (*Prunus angustifolia watsoni*) has often been suggested as a stock for dwarfing other plums. A few experiments have been made with it, but no conclusions have been reached.

Sand cherry.—The western Sand cherry (*Prunus pumila besseyi*) has been tested to a considerable extent in the northwestern states. It is very hardy; and this seems to be its chief claim to notice. It distinctly dwarfs the varieties worked on it. It is said by Craig and others to make a satisfactory union. The fact that the reciprocal graft with Marianna makes a good union, may be indicative of its affinity for some of the common plums. This is one of the most interesting of the experimental stocks.[1]



Fig, 5. DOMESTICA ON NIGRA

Badly overgrown—dead

Choke cherry.—This species has also been tried in a few cases as a stock for plums, but has never proved satisfactory.

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[1] “While the experiments under way in Iowa, South Dakota and other places have not continued long enough to determine fully its value, the present indications are (1) The roots are perfectly hardy in our worst winters. (2) The tree of Americana varieties will be dwarfed to perhaps two-thirds full size, but will bear very early. (3) For amateur culture in small gardens there is an excellent field for Americana plums on Sand cherry stocks, providing the trees will not need too much care in heading back to prevent getting top-heavy.”—*N. E. Hansen, in Am. Asso. Nurserymen Rpt. 1900, p. 56.*

Black cherry.—The common black cherry (*Prunus serotina*) has also been tried; and Mr. Kerr now has a few trees of Chicasaw varieties growing on this stock. The union, however, is unpromising.

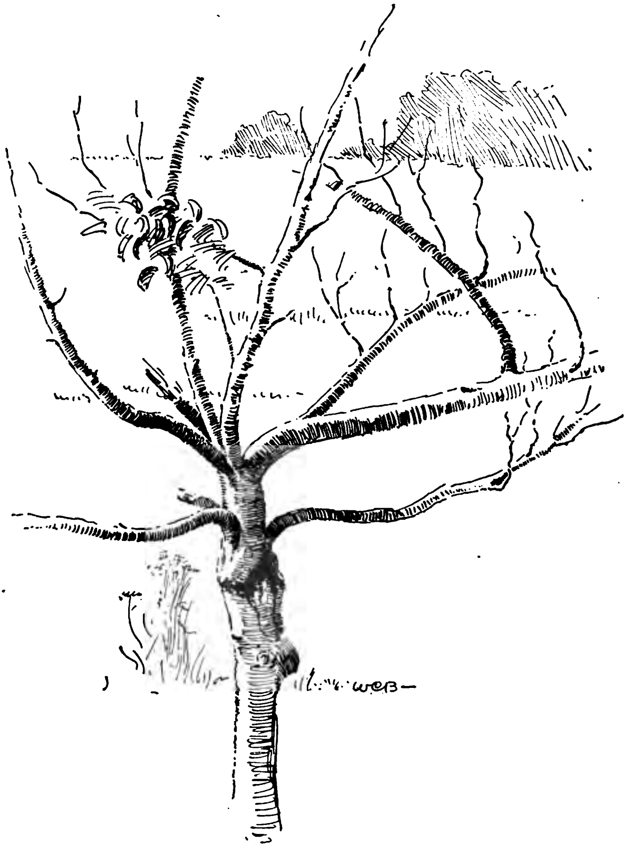


Fig. 6. SAND CHERRY ON NIGRA

A poor union

Peach.—Peach pits are always available at the canneries at a low price, the seeds usually germinate freely and the seedlings grow strongly. For this reason the stocks are almost always cheap. Many nurserymen have used them on that account. But they have certain real merits beyond their cheapness. They unite well with many of the different classes of plums, especially with the freer growing sorts, and more particularly with the Japanese varieties. The trees seem to be thrifty, healthy and long-lived.

In the case of plums propagated on peach roots, grafting is much better than budding, which is an empiricism of some interest.

Apricot.—Apricots are extensively canned in some sections, especially on the Pacific coast; and wherever they are canned the pits are of course available for growing for stocks. They have been used for plums to some extent; but so far as the writer can learn, are somewhat inferior.

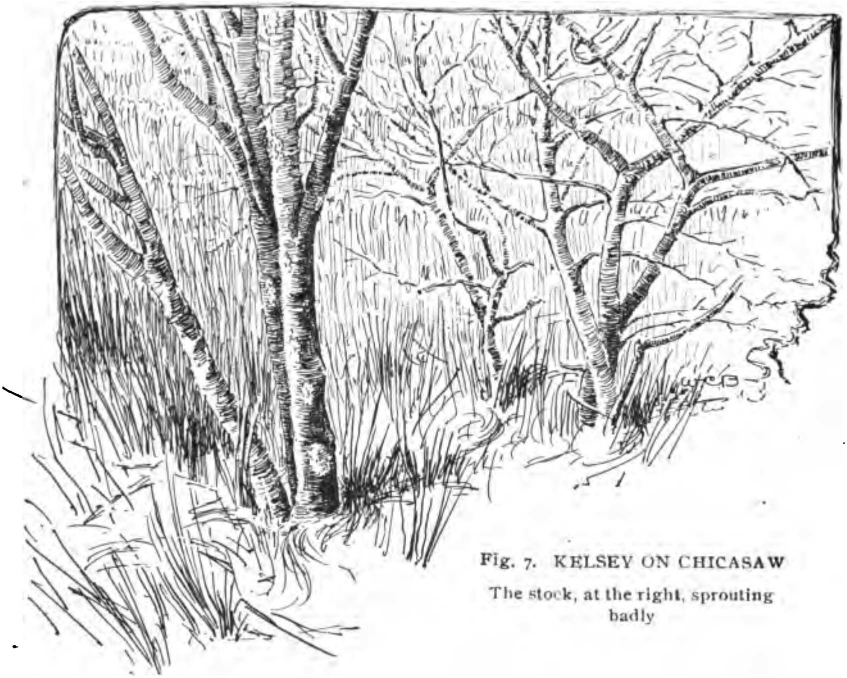


Fig. 7. KELSEY ON CHICASAW

The stock, at the right, sprouting badly

Besides the stocks mentioned here, several others have been tested in a very small way. The wild Bird cherry, *Prunus pennsylvanica*, has been tested somewhat, and gives some promise. In California the Pacific coast plum, *Prunus subcordata*, has been tried, but dwarfed the cions too much and proved unsatisfactory.

III. RESULTS OF NURSERY EXPERIMENTS

Experiments in the propagation of plums were begun by this station in the spring of 1899. Five varieties were propagated in four lots, each on four different stocks. The five varieties represented five distinct classes of plums—the most important groups in cultivation—and were as follows:

I. Stoddard, of the Americana group.
II. Green Gage, of the Domestica group.
III. Chabot, of the Japanese group.
IV. Milton, of the Wildgoose group.
V. Newman, of the Chicasaw group.

The four different stocks used were as follows:

a. Americana. Seedlings grown in Iowa.
b. Wayland type. Seedlings grown in Maryland.
c. Marianna. Cuttings grown in Maryland.
d. Peach. Seedlings grown in Maryland.

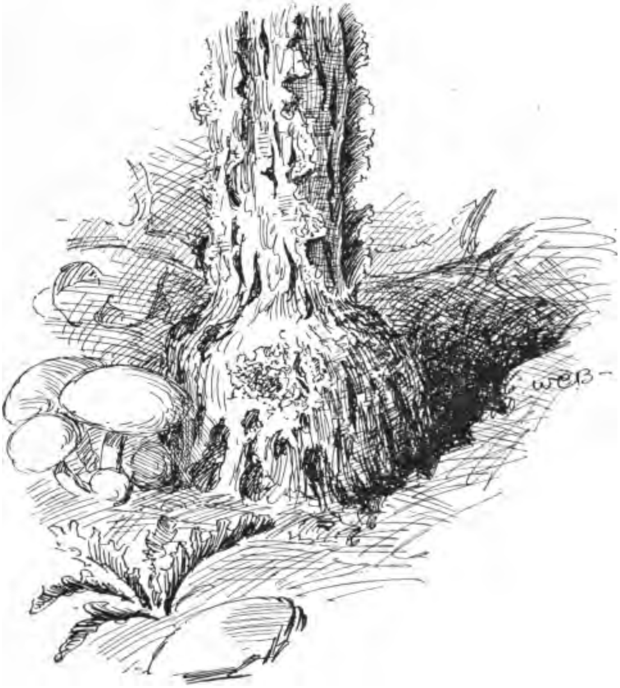


Fig 8. AMERICANA ON PEACH

The stock is overgrowing

As each variety was propagated on each stock, this made twenty lots in the experiment. The grafts were made by Mr. J. W. Kerr of Denton, Md., one of the most expert propagators of plums in America. The work was done by the whip-graft method commonly employed with apples. The cions were made about five inches long. The stocks were piece roots, of the usual length, that is, about four to five inches.

The grafts were made in winter, and packed in saw-dust. They were set in spring in nursery rows, in Mr. Kerr's nursery, at Denton. The soil there is very sandy and loose, though well enriched with manure. An excellent growth was secured from the grafts in this experiment, as from other stock in adjacent rows. The season was fairly favorable. Conditions, on the whole, were entirely normal, so that there was nothing to interfere with the progress of the experiment.

From the outset there were striking differences among the different lots. These were, of course, very interesting, especially from the nurseryman's point of view. At the end of the season these differences were still very marked, so much so that it is thought worth while to make a report of observations. In general, the fruit grower is interested only in getting a good, sound, healthy, comely tree from the nursery, and he cares very little by what method it is grown. He seldom inquires, even, as to what sort of a stock the top has been propagated on. Doubtless the tree planter might properly be more careful as to the stocks which he buys with his tree-tops. Doubtless, also, the differing influences of different stocks will continue to have some influence after the trees are planted in the orchard, and, perhaps, even after they come into bearing. With this in view, we have planted the best trees of each lot in a permanent orchard on the station grounds at Burlington, for future observation; but the experiment in its present state of progress is useful principally to the propagator.

The trees were dug in the spring of 1900. They were graded and measured, and full notes and photographs were made of each lot.

The following digest of the notes taken will serve to show the general character of the several lots. It should be remembered that 30 grafts of each lot were set.

NOTES ON ONE-YEAR-OLD TREES

Ia. Stoddard on Americana; 24 trees. Mostly straight clean whips, first-class. Root system strong and well branched, strongly one-sided, with many fibrous roots. Several worthless trees, however.

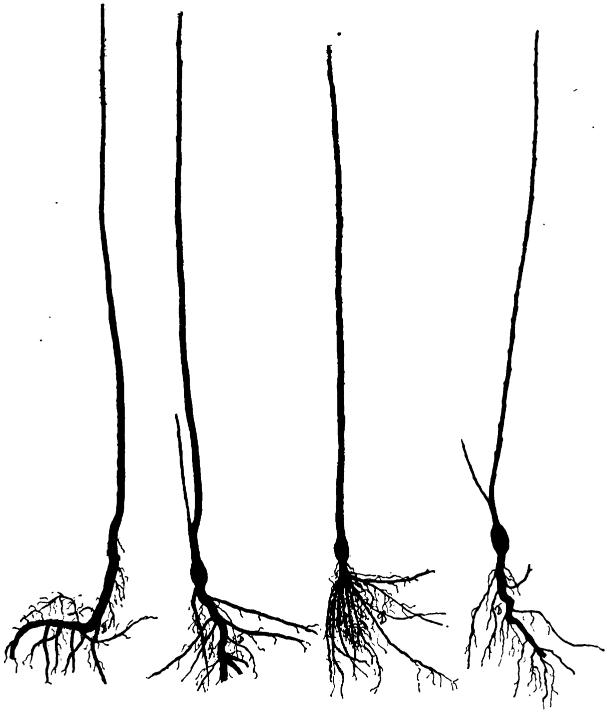
Ib. Stoddard on Wayland; 17 trees. Mostly whips, or slightly branched; clean and fine. Root system a little straggling and unsymmetrical, but good and well branched; moderately fibrous.

Ic. Stoddard on Marianna; 12 trees. Mostly clean straight whips. Root system smaller and less symmetrical than in lot Vc,—Newman on Marianna,—but fairly good.

Id. Stoddard on peach; 15 trees. Mostly clean straight whips. Root system consisting chiefly of a straight or spiral tap-root, running directly downward, strongly branching below; in this respect differing markedly from lot IId,—Green Gage on peach.

IIa. Green Gage on Americana; 10 trees. Tops small and very scrubby. Roots very poor; not branched; mostly only a single straight stub.

IIb. Green Gage on Wayland; 9 trees. Trees small, but better than the average of Green Gage in this experiment. Root system striking downward; unsymmetrical; branched; moderately fibrous.



Gig. 9. STODDARD

On Americana, Wayland, Marianna, and peach roots, in this order

IIc. Green Gage on Marianna; 9 trees. A bad lot; small, branched and gnarly. Roots fairly good, as compared with tops, somewhat branched, having a few fibres.

IId. Green Gage on peach; 12 trees. Two trees clean and straight, though small; the rest small, branched, gnarly, bad. Root system of a single, unbranched tap root in every case.

IIIa. Chabot on Americana; 27 trees. Large, very thrifty, considerably branched. Root system irregular, usually somewhat one sided, finely branched, and moderately fibrous.

IIIb. Chabot on Wayland ; 8 trees. Trees medium size, a little irregular in form. Root system not very good ; only a moderate number of branches and a few fibrous roots.

IIIc. Chabot on Marianna ; 2 trees. Strong, straight, well branched trees. Root system strong and well branched, with a moderate amount of fibrous roots.

IIId. Chabot on peach ; 16 trees. Large, strong, and well branched. Root system strong, symmetrical, somewhat branched, with a moderate amount of fibrous roots.

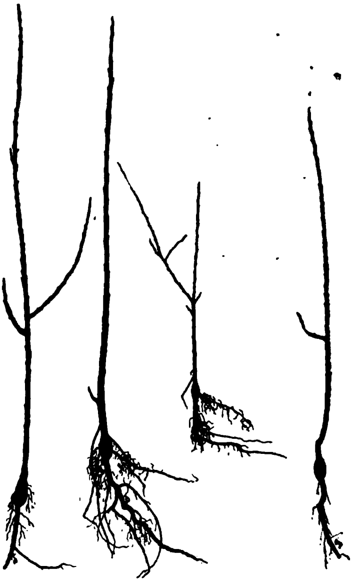


Fig. 10. GREEN GAGE

On Americana, Wayland, Marianna, and peach roots, in this order

IVa. Milton on Americana ; 17 trees. Trees variable ; many small ; larger ones well branched. Root system poor, one sided; moderately fibrous.

IVb. Milton on Wayland ; 14 trees. Trees *fine;* mostly straight, clean whips, or with a few small branches. Root system one-sided, but good ; well branched, with moderate amount of fibrous roots.

IVc. Milton on Marianna; 14 trees. Large, thrifty, fine, strongly branched. Root system large, much branched, fairly symmetrical, and moderately fibrous.

IVd. Milton onpeach ; 9 trees. *A bad lot ;* scrawny, branched, small. Roots mostly straight taps, slightly twisted, with a very few straggling branches.

Va. Newman on Americana ; 21 trees. Fine, lusty, and strongly branched. Root system strong and fine ; usually with a stiff but crooked tap-root, well branched and moderately fibrous.

Vb. Newman on Wayland ; 12 trees. Trees thrifty and strongly branched ; some badly branched from the base. Root system not symmetrical, but well branched, and moderately fibrous.

Vc. Newman on Marianna ; 6 trees. Well branched, strong and fine. Root system first class, well branched and well supplied with fibres.

Vd. Newman on peach ; 21 trees. Strong and much branched, *fine.* Root system strongly vertical, somewhat branched, fair to good, with few fibres.

General observations.—The best and most typical tree of each lot was selected and photographed. These photographs have been carefully redrawn and here reproduced as figures 9, 10, 11, 12 and 13. They will explain some things much better than the notes.

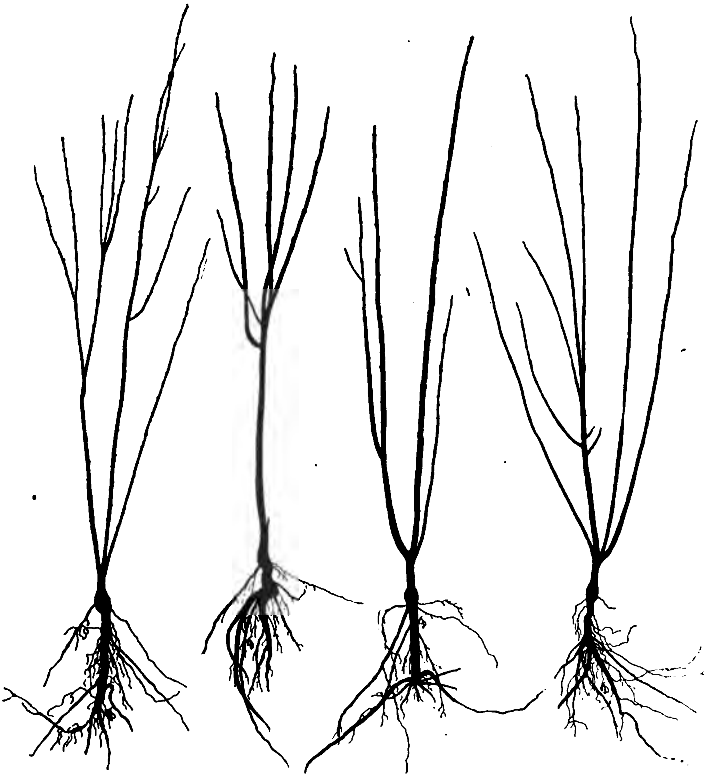


Fig. 11. CHABOT
On Americana, Wayland, Marianna, and peach roots, in this order

From a consultation of the notes and the pictures it will be seen that the several varieties used in this experiment differ markedly in their habit of growth. Stoddard is almost always a straight, clean whip at one year old. Green Gage is a weak and erratic grower. Chabot is a very strong grower, and apt to branch from near the base. Milton is a strong but rather willowy tree, with more or fewer branches. Newman is a very strong grower, with many divergent thorny branches.

The character of the top in any given variety, however, seems to be influenced somewhat by the stock on which it is grown. In the first place a much larger proportion of the cions live on one stock than on another. Secondly, their amount of growth for the season is influenced. Thirdly, the tendency to branch seems to be influenced somewhat by the stock in a few cases, as, for instance, the trees on Americana stocks seemed to be more irregularly branched than on other stocks, especially as compared with those on peach.

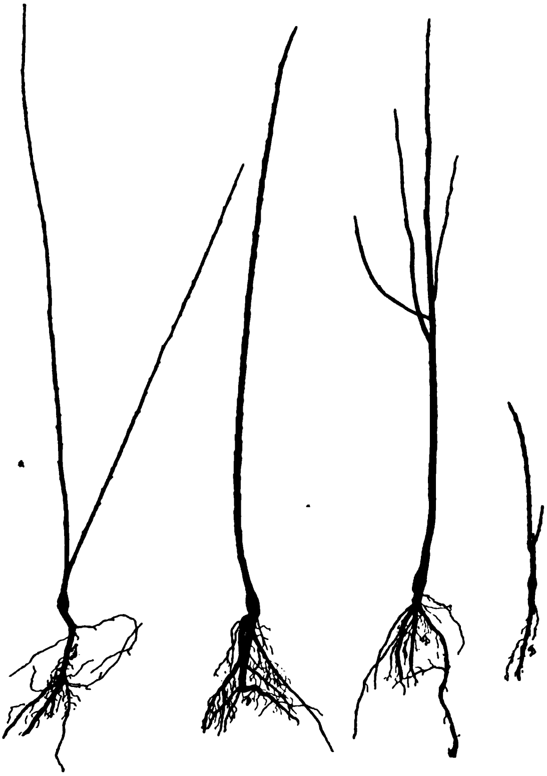


Fig. 12. MILTON
On Americana, Wayland, Marianna. and peach roots, in this order

Even a casual examination of the pictures and notes will show also that the several sorts of stocks used differ markedly from one another in their habits of growth. The Americana roots are almost uniformly unsymmetrical, bending strongly to one side. They usually show several stiff secondary roots, which do not set off horizontally from the main root, however. There are usually a moderate number of fibrous roots. The Wayland stocks give a root system intermediate between the Americanas and Marianna. It is somewhat inclined to develop a stiff tap-root with a curve to one side. There are several secondary roots, rather longer and more slender than on the Americanas. and more inclined to be horizontal. There seem to be generally more fibrous roots on trees of the same size. Marianna stocks usually develop a straight tap-root, but this is much less conspicuous than in Americana or even than in Wayland root systems. There are usually more secondary roots, and they are longer and slenderer, than in the foregoing groups. Fibrous roots are usually present in fair amount. Peach stocks show always a very large tap-root, running straight downward. This is sometimes strongly twisted into a spiral of small diameter. There are seldom any secondary roots, or if there are, they come out low down on the tap-root. Fibrous roots are sparse and hardly worth mentioning. The root system developed by the peach on one year old plum trees is evidently the poorest of any in this experiment.

One of the most interesting,—and somewhat remarkable,—things in this experiment is the manner in which the cion apparently influences the stock. For instance, Stoddard tops seem to give some of the curved tap-root character of the Americanas to all the stocks on which they grow. (This point is not well brought out in the notes and pictures, but was more apparent in an examination of the trees themselves). One interesting point was in the way in which Stoddard tops induced a conspicuous branching of the root system when worked on peach. With other varieties the peach gave almost always a clean, unbranched tap-root. The weak growth of Green Gage naturally served to induce only a weak growth in most of the stocks on which it was worked; while the rampant growth of Chabot had exactly the opposite effect. The strongly branching root systems found on Chabot trees were probably due in part to the energetic way in which the foliage acted during the growing season. Marianna stocks, which seemed to be uncongenial to Milton, giving only a poor union, made very little growth when grafted with Milton cions. No other case was observed in which Milton appeared to have any influence on its stock. Newman seemed to influence all stocks in the way of giving off more secondary roots. Nearly all stocks when grafted with Newman gave a strong vigorous growth. considerably above the average, tending at the same time to produce more both of secondary roots and of fibres.

It will not do to press this point too far. The question of how the stock may influence the cion has been mooted ever since grafting was practiced. The question of how the cion may influence the stock has been still more obscure. No fundamental principles are established by this experiment; but it seems fair to believe that we have here one of the few authentic cases of record in which definite tangible changes in the root system have been induced by the character of the cion.

Other observations and measurements are recorded in the following table. The term "merchantable trees" applies to all trees above three feet in height which were clean and straight enough to pass with an ordinary buyer. It was not found feasible to separate the lots into "firsts" and "seconds." But those trees classed as "merchantable" were very much such stock as is sold by the better nurserymen on orders for one year old plum trees.

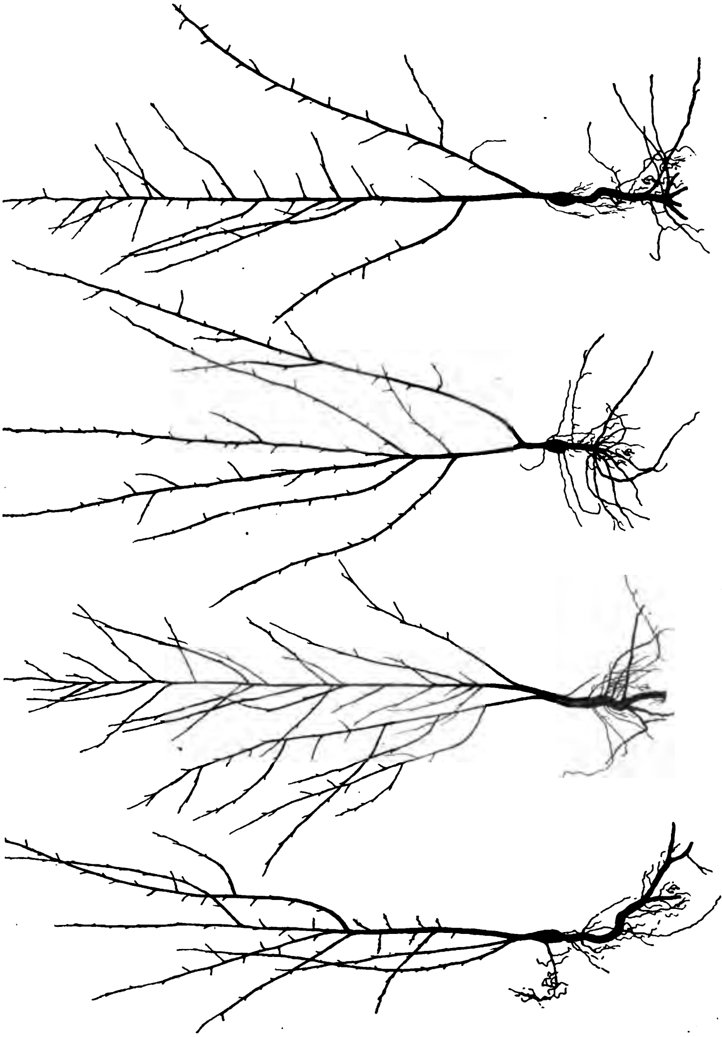


Fig. 13. NEWMAN

On Americana, Wayland, Marianna, and peach roots, in this order

TABLE GIVING MEMORANDA OF TREES

Description	Total number of trees*	Extreme hight in feet	Average hight in feet	Number of merchantable trees	Percent of merchantable trees
Stoddard :					
(Ia) On Americana	24	5.00	2.50	10	42
(Ib) On Wayland	17	4.50	2.89	10	59
(Ic) On Marianna	12	4.33	3.42	8	67
(Id) On peach	15	4.00	2.08	3	20
Green Gage :					
(IIa) On Americana	10	3.50	1.71	2	20
(IIb) On Wayland	9	4.25	2.17	3	33
(IIc) On Marianna	9	1.50	1.04	0	0
(IId) On peach	12	4.50	1.58	1	8
Chabot :					
(IIIa) On Americana	27	6.00	3.92	24	89
(IIIb) On Wayland	8	4.17	3.42	5	63
(IIIc) On Marianna	2	5.50	4.75	2	100
(IIId) On peach	16	5.50	4.08	14	89
Milton .					
(IVa) On Americana	17	5.00	3.08	10	59
(IVb) On Wayland	14	5.75	4.75	12	86
(IVc) On Marianna	14	4.50	3.50	12	86
(IVd) On peach	9	1.25	0.81	0	0
Newman :					
(Va) On Americana	21	5.00	3.65	18	86
(Vb) On Wayland	12	4.50	3.90	11	92
(Vc) On Marianna	6	4.00	3.58	5	83
(Vd) On peach	21	5.00	3.90	20	95

* Thirty grafts in each lot were planted.

The data contained in the foregoing table are summarized herewith :

AS TO VARIETIES PROPAGATED : AVERAGES

Description	Total trees in each lot	Extreme hight in feet	Average hight in feet	Number merchantable	Per cent merchantable
Stoddard	17.00	4.46	2.72	7.75	47
Green Gage	7.50	3.44	1.62	1.50	20
Chabot	13.25	5.29	4.04	11.25	85
Milton	13.50	4.13	3.03	8.50	58
Newman	15.00	4.62	3.76	13.50	89

AS TO STOCKS USED : AVERAGES

Americana	19.8	4.90	2.97	12.8	59
Wayland	12.0	4.63	3.43	8.2	67
Marianna	8.6	3.97	3.26	5.6	67
Peach	14.6	4.05	2.49	7.6	42

Doubtless we ought to apologize for drawing any conclusions from a single experiment and in a preliminary report. Nevertheless we shall take the liberty of mentioning some of the most obvious facts brought out by the data presented above. The following statements are true and accurate, of course, for the experiment in hand. As to how far they would hold good in other years, in other soils and in other climates, remains to be seen. Probably many of these data would be verified in other experiments.

Comparison of varieties.—It will be seen that Stoddard gave the largest average number of trees in each lot; Chabot gave the greatest average height, considering either extremes or averages; while Newman gave the largest average number and percentage of merchantable trees. Green Gage gave the lowest average in every column. These figures indicate that Green Gage is comparatively very difficult to propagate; whereas Newman and Chabot are comparatively easy. The figures emphasize these conclusions less than an examination of the trees would.

Comparison of stocks.—It will be seen that the Americana stocks gave the largest average total of trees in each lot, the tallest trees (extreme hight considered), and considerably the largest number of merchantable trees. This is somewhat remarkable. Americana stocks have come into use only in the northwest and only because they are understood to be extremely hardy. It is altogether unexpected that they should outrank peach and Marianna stocks in the production of good, clean merchantable trees in a southern nursery and in a sandy soil. This is perhaps the most striking fact brought out by the experiment. On the other hand the Marianna, —still considered the best stock in many southern nurseries,—gave much the smallest number of trees, considering either the total or the merchantable product.

General result.—If we go behind the averages, however, we find that they cover a number of inequalities. These inequalities, moreover, are quite as significant in some cases as the averages. Thus we find that Stoddard—an Americana—did better on Americana roots than on any other, though the Wayland stocks gave equal results as regards number of merchantable trees and a greater average size. Green Gage seems to have done best on Wayland stocks, and to have been a failure on Marianna,— a stock on which it is often propagated commercially. Chabot gave by far the best result on Americana roots, though it has generally been supposed that Marianna and peach stocks were specially congenial to the Japanese plums. Milton made the best showing on Wayland stocks, while it was practically a failure on peach. This last point was very striking, and came much in the nature of a surprise. Peach stocks have been supposed to be suitable for all the plums of the Wildgoose type. Newman did best on peach, which is according to current opinion; but it gave second best results on Americana, which is not in agreement with the nursery notions commonly held. It was poorest of all on Marianna roots, though Marianna has often been specially recommended for propagating all the Chicasaws.

We therefore arrive at this important notion: that a given variety does not do equally well on all stocks, and, vice versa, that a given stock is not equally adapted to all varieties. In other words, the fullest success is reached by grafting a cion upon a stock which is specially adapted to it. This is a refinement of nursery practice which the ordinary nurseryman is probably not prepared to adopt. It might, nevertheless, be worth his while to do so in certain cases. It seems fair to believe, in view of the figures here given, that a nurseryman might have three or four sorts of stocks on hand; and that he might with advantage work each variety which he propagates upon the stock which is best for it. A difference of 10 to 20 per cent in the merchantable product is the difference between a losing business and money in the bank.

The man who is seeking an all-purpose stock will naturally confine his examination of these figures to the averages. The principal lesson which they teach is, that Americana stocks are worthy of more careful trial by many nurserymen and private propagators.

IV. LATER NOTES

Delay in the publication of this report enables us to add our observations of the behavior of these trees during the summer of 1900. As has been related, three of the best trees from each lot were selected and planted in permanent orchard arrangement on the station grounds in Burlington.

The average growth of these several lots is shown in the following table:

AVERAGE GROWTH IN ORCHARD

Measurements in inches

	On Americana	On Wayland	On Marianna	On Peach	Average
Stoddard	24	17½	15	10	16.6
Green Gage	11	16	13	18	14.5
Chabot	34	34	37½	18	30.9
Milton	28	37	38	0	25.7
Newman	33	37	26	24	30.0
Average	26.0	28.3	25.9	14.0	25.3

Stoddard (Americana) made the strongest growth and did best in every particular on Americana roots. It was second best on Wayland roots, and decidedly unsatisfactory on peach.

Green Gage (Domestica) is a poor grower at best. The best trees seem to be those on Wayland, with Americana second best.

Chabot (Japanese) is a rank grower. It did best on Marianna and Wayland, whereas it was decidedly poor on peach, one tree out of three having died besides.

Milton (Wildgoose group) made a splendid growth on all stocks but peach. Every tree on peach died. Out of the thirty propagated, not one remains at the end of the second year. This result is remarkable. Wayand and Marianna gave about equal results.

Newman (Chicasaw) is a vigorous grower, though not comely. It did best on Wayland roots, second best on Americana roots. The peach stocks, which gave best results last year in Mr. Kerr's sandy Maryland nursery, gave distinctly poorest results during this first year in the Vermont orchard.

All the trees did fairly well, excepting Green Gage, and making due allowance for the unfavorable growing season, they did uncommonly well. A further exception, however, should be made for those on peach roots. The peach stocks have made a very poor showing in the orchard. Every lot on peach is inferior to the same variety on any other stock whatever.

The trees remaining after the orchard was planted, were "rowed out," as the nurserymen say, in nursery rows, about a foot apart in the row. The following notes taken from these nursery rows, will have some interest:

Stoddard on Americana.—21 trees planted; 16 living, good and thrifty.
Stoddard on Wayland.—14 planted; 10 living, good.
Stoddard on Marianna.—9 planted; 5 living, fair.
Stoddard on peach.—12 planted; 8 living, stunted appearance.
Green Gage on Americana.—7 planted; 4 living, poor.
Green Gage on Wayland.—6 planted; 4 living, good.
Green Gage on Marianna.—6 planted; 3 living, poor.
Green Gage on peach.—9 planted; 4 living, poor, straggling.
Chabot on Americana.—24 planted; 11 living, rather poor and uneven.
Chabot on Wayland.—5 planted; 5 living, rather poor.
Chabot on Marianna.—None left over.
Chabot on peach.—13 planted; all dead, not one started.
Milton on Americana.—14 planted; 7 living, extra fine.
Milton on Wayland.—11 planted; 9 living, fine.
Milton on Marianna.—11 planted; 9 living, extra fine.
Milton on peach.—6 planted; all dead.
Newman on Americana.—18 planted; 16 living, extra good.
Newman on Wayland—9 planted; 8 living, extra good.
Newman on Marianna.—3 planted; 3 living, good.
Newman on peach.—18 planted; 18 living, fine and thrifty.

These notes give additional evidence (except in the case of Newman) on the unsuitability of the peach stocks to our soil and season.

FURTHER WORK IN PLUM POLLINATION

Four reports on experments in the pollination of plums have already been made by this station.[1] The general practical problems have been cleared up to a degree which has seemed to justify the more particular study of certain special questions bearing on the subject. The experiments have been continued during the past year, therefore, along somewhat restricted lines. A brief report of such work as has been completed up to date follows herewith.

I.. STUDIES OF POLLEN

The plum blossom consists of two essential parts, the pistil, or female organ, and a whorl of stamens, or male organs. The normal and abnormal forms of the pistil were extensively studied at the outset of our experimental work, and the relation of the various malformations to pollination was fully considered. Some attention was also given to the production of pollen, to the variations of the male organs and to possible fluctuations in the efficiency of their work. Pollen and pollen production, however, were not so exhaustively studied as it seemed they ought to be; and to this subject, therefore, some further attention has been directed during the past year.

A great many samples of pollen were examined under the microscope and tested for germination. The results of these examinations and tests are presented in the accompanying table.

Germination tests were made chiefly in drop cultures on microscope slides in five percent sugar solution. Various methods were tried, and sugar solutions of varying strength, from three percent to twenty percent, were tested. Though there seemed to be little difference in pollen germinations following the variations in strength of the solutions, the five percent solution gave, on the whole, greatest uniformity of results, and was therefore adopted as the standard strength for the regular series of experiments.

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[1] Vt. Exp. Sta. Bul. 53 (1896). Rpt. 10, p. 87-96 (1897). Rpt. 11, p. 238-262 (1898). Rpt. 12 p. 189-209 (1899).

TABLE OF POLLEN GERMINATION TESTS

Variety	Group	Localities	Character of pollen	Germination
Abundance	Japanese	Ithaca, N. Y.	irregular	----
"	"	"		10%
"	"	"		good
Apple (N)*	Hybrid	Maryland	irregular	----
Bavay	Domestica	Ithaca, N. Y.		40%
Beatty	Chicasaw	Maryland	abundant	none
Berger	Japanese	"		40%
"	"	"		43%
"	"	"		41%
"	"	"		70%
"	"	"	fine, large	good
Captain	Wayland	"	fine, abundant	weak
Champion	Americana	Georgia		20%
"	"	"		3%
Clyman	Domestica	Ithaca, N. Y.	fine	----
Crescent (4)†	Americana	Georgia		good
Cumberland	Wayland	Maryland	fine, abundant	poor
Deepcreek (N)	Americana	"	fine, large	good
Empire	Domestica	Ithaca, N. Y.	scant	fair
"	"	"		10%
Excelsior	Hybrid	Maryland	small, scant	none
Gonzales	"	"	small, irregular	none
Grand Duke	Domestica	Ithaca, N. Y.	good	none
Imperial Gage	"	"		good
Itasca (N)	Nigra	Maryland		fair
Jas. Vick	Wildgoose	"		weak
Jefferson	Domestica	Ithaca, N. Y.		40%
"	"	"		20%
Kroh‡	Wildgoose	Maryland	fine, abundant	extra
Lombard	Domestica	Ithaca, N. Y.	good	----
Longfruit	Japanese	Maryland		poor
Macedonia	Wildgoose	"		weak
Munson	Chicasaw	"	small but plump	good
Nebraska	Miner	Georgia		good
Nimon	Wayland	Maryland		weak
Osage	Wildgoose	"		poor
Piram	Chicasaw	"	fine, abundant	fair
Quaker	Americana	"		25%
"	"	"		32%
Richland	Domestica	"	abundant	none
Robinson (N)	Chicasaw	"	good, abundant	poor
Roulette (N)	Wildgoose	"	good	poor
Satsuma	Japanese	"		poor
Schley	Wildgoose	"		none
Smith	Americana	Georgia		11%
"	"	"		20%
Sophie	Wildgoose	Maryland	poor	none
Strawberry	Watson	"	good	strong
Texas Belle	Wildgoose	"	poor	poor
Wayland	Wayland	"	fine	poor
Wazata	Nigra	"	poor	moderate
Wickson	Hybrid	"		37%
"	"	"		34%
"	"	"		30%
"	"	"		none
"	"	"		good
"	"	Ithaca, N. Y.	very small	none
"	"	"		8%
Wildgoose	Wildgoose	Maryland		14%
"	"	"		16%
"	"	"	small grains	poor
"	"	"		poor
"	"	"		poor
"	"	"		none
"	"	"		extra
Wooten (N)	"	"		none
" (5)†	"	Oklahoma		good
Yel. Transparent	Chicasaw	Maryland	small	poor

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* (N) This character stands for "nursery." The trees from which these samples of pollen were taken stood in nursery rows. They were two years old.

†Figures in parenthesis give number of samples taken.

‡This tree was badly attacked by monilia.

The conclusions which we reached from our studies of pollen, including an analysis of the data presented in the foregoing table, may be summarized as follows:

1. Pollen varies greatly in quantity, though in most cases it is in such large supply as to insure adequate pollination. The instances of deficient quantity seemed to occur most frequently among hybrid varieties.

2. Pollen also varies in the size and plumpness of the grains. Many grains are seen, on microscopic examination, to be small, empty or collapsed. In earlier observations[1] it was found that grains which appeared normal to the eye were sometimes lacking of protoplasmic contents, indicating their uselessness for purposes of fecundation. These irregularities also appear to be unusually frequent among varieties of hybrid origin.

The observations under 1 and 2 above seem to give an affirmative reply to one of the queries propounded four years ago[2]: "Will the continued intercrossing and hybridizing of sorts in the orchard tend to produce varieties characterized by increasing sexual weakness?" This conclusion can not be emphasized, however, on the basis of present observations.

3. Pollen varies in germinating power. In culture experiments it varies excessively, though the germination is, on the whole, always surprisingly low. It may be fairly doubted whether experimental conditions are nearly enough like natural conditions to make experimental pollen germinations fairly representative of what takes place in the orchard. The microscopic examination of stigmas at pollinating time, it should be said, always showed an abundance of germinating pollen grains. Still there is nothing to throw doubt upon the general conclusion of this paragraph, that pollen varies in germinating power.

4. It is impossible, with data now at hand, to assign any causes to these fluctuations in quantity, size, and viability of pollen. Trees severely assailed by monilia (which have hitherto shown a striking tendency to produce imperfect pistils[3]) gave unusually fine samples of pollen, showing extra germinating power. See Kroh, table, page 356. Small nursery trees (which often show weak pistils when they blossom[4]) yielded pollen apparently as good as any. Pollen taken during rainy weather seemed to germinate as well as that taken during the most propitious days.

5. It seems probable that the germination of plum pollen is not readily influenced by ordinary external conditions. Germination in cultures of

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[1] Vt. Exp. Sta. Bul. 53, p. 54 (1896).

[2] Vt. Exp. Sta. Bul. 53. p. 64 (1896).

[3] See Vt. Exp. Sta. Rpt. 10, p. 91 (1897).

[4] See loc. cit.

sugar solution may fairly be regarded as an extraordinary condition, yet the pollen did not seem to be sensitive to differences of ten to fifteen per cent in the strength of the solution. Where pollen was observed on the stigmas of the blossoms, it invariably showed a strong germination.

6. From the standpoint of the practical plum planter, there seems to be only one conclusion of consequence to be drawn from the study of pollen and pollen production; namely, that certain hybrid varieties, notably Wickson and Excelsior, probably also Gonzales and others, can not be relied on for the pollination of other varieties, even though other conditions of simultaneous blossoming, etc., be fully met.

II. MALFORMATION OF BLOSSOMS

In connection with the observations recorded under 1 and 2 above, to the effect that certain hybrid plums show a tendency towards defectiveness of the male organs, it may be worth while to put on record certain notes of malformed blossoms. These malformations were found chiefly in hybrid varieties, and usually in the stamens. The most striking cases are those of Mr. J. W. Kerr's so-called Mule, a hybrid of Troth Early peach and Wildgoose plum[1] and in Mr. G. L. Taber's Excelsior, a hybrid of Kelsey with Wildgoose (probably).[2]

In Mule there are no petals and no pistils. There are a large number of stamens which, however, have more the form of pistils than of stamens. The usual form is shown in figure 1. This form is fairly constant. There is a slight swelling at the base of the stamen, showing an incipient ovary; while the organ is surmounted with a small head which partakes more of the nature of a stigma than of an anther. The surface of this anther or stigma is not entirely smooth, but has a tendency to be granular, like the common stigmatic surface.

There has been no recent opportunity for an examination of the organs of Blackman plum, another peach-plum hybrid[3]; but according to the writer's recollection, the structure of the blossoms is almost exactly as in Mule.

Excelsior is more interesting. Mule and Blackman are both necessarily and irremediably sterile; but Excelsior usually bears fair crops, even on the trees which show the malformations here described. These deformities of the flowers have been carefully noted for two years, on two large trees in the orchard of Mr. J. W. Kerr. The blossoms usually have pistils which appear to be perfect, though weak. Occasionally pistils are wanting. The stamens, however, show all degrees of malformation, from the normal form up to nearly perfect pistils. The more common forms are shown in figure 2. The stamen shown at *a* is nearly normal, having only a slight prolon-

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[1] See Vt. Exp. Sta. Bul. 67, p. 17 (1898).

[2] Ibid, page 11.

[3] Ib}d page 7.

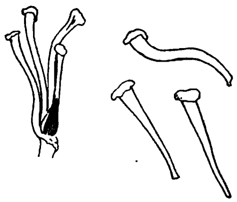

Fig. 1. Dissection of blossoms of Mule.

gation at the apex. The one at *b* is still further extended upwards, and the prolongation has distinctly the aspect of a style and stigma. The anther itself is split down the front, appearing to be half dehisced, but really approaching the form shown at *c*, which is still more pistil-like. Here the appearance of stigma and style are still more pronounced, and the body of the anther has split open, showing distinctly the morphology of a leaf. Upon either margin of this leaf-like anther-ovary, an ovule is borne. These ovules are conspicuous and unmistakable in the forms shown at *c*, *d*, *e* and *f*. Occasionally they are enclosed in the ovary-like organ, in which case the transformation from stamen to pistil is nearly complete.

All these stages may be found in a single flower, along with normal stamens bearing viable pollen.

Abortive seeds are somewhat frequently found in hybrid plums, especially in certain varieties.

A wild tree of *Prunus americana* bearing flowers without petals, has been recorded, also one bearing flowers without pistils. Other varieties have been observed which frequently bear double or triple pistils.[1]

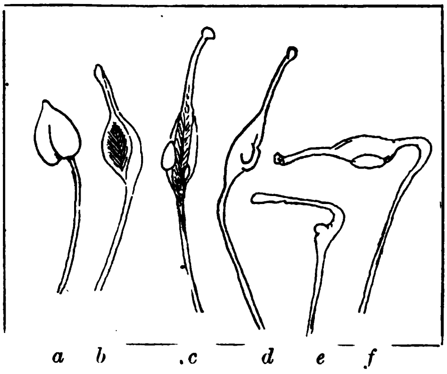

Fig. 2. DISSECTION OF EXCELSIOR.

III. TRANSPORTATION OF POLLEN

There is a very general belief that pollen is transported from tree to tree in the orchard by wind and by bees. The popular notion seems to give about equal credit to these two agencies. Experiments already reported by this station[2] have tended to show that plum pollen is carried almost exclusively by insects, and that the wind has little or no part in the work.

This year it occurred to the writer to determine whether or not plum pollen is really transported by wind, without immediate reference to the question of pollination. For this experiment a number of glass slips were taken, such as are used in microscopes. These were labeled at one end; and the remainder of each slip was painted with a mixture of vaseline and lampblack. These slips were then exposed in various parts of the plum orchard. The vaseline caught whatever pollen was carried against the slip; and the lampblack made the grains more visible. (At least it was expected that the lampblack would help. It is doubtful whether it did or not).

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[1] See Vt. Exp. Sta. Bul. 53, p. 51 (1896).

[2] Vt. Exp. Sta. Rpt. 11, p. 245 (1898). Rpt. 12, p. 201, (1899).

When the slips were taken down, they were carefully examined with a hand lens of sufficient power to detect any grains of pollen; and the positions of all such grains, or pollen masses, were carefully noted on blank slips in the field record. From these were made the drawings reproduced in figure 3, which show, therefore, with fair accuracy, the results of this test.

These experiments were made on the 24th and 25th of April. The slips were put in place at one o'clock. At this time there was a steady wind of about five miles an hour,.which continued until sundown. The day was warm, bright and clear; the trees were in the height of the blooming season, and the bees were at work in armies. The forenoon of the 25th was hardly so warm, but there was a fine fresh northwest wind, of at least ten miles an hour.

Slip A was placed in the midst of an orchard of Wildgoose plums in full bloom. It was set at a hight of six feet from the ground and midway, east and west, between two large plum trees, at a distance of about ten feet from each, the wind being in the north. After staying in place twenty-four hours it had not caught a single pollen grain.

Slip B was set about fifteen feet to the north of a large Wildgoose tree and at a hight of six feet, facing the tree. At the end of twenty-four hours it had not caught a single pollen grain.

Slip C was set about six feet from the ground, about ten feet from, and facing, a large Wildgoose tree, and directly in the course of the wind. At the end of twenty-four hours it had caught twenty-five pollen grains and pollen masses, *mostly masses*. The positions of these masses are shown on slip C, figure 3.

Slip D was placed face up on the ground underneath a large Wildgoose tree. At the end of two hours it had caught one pollen mass.

Slip E was set at a hight of two feet from the ground in the midst of a large mixed orchard of Wayland, Whitaker, Sophie, Newman and Clark, nearly all in full bloom. It was less than ten feet from each of four large trees in full bloom. At the end of twenty and a half hours it had caught seven pollen grains and masses.

Bearing in mind that this test was made at the hight of the pollinating season and under the most favorable conditions possible, it will be seen that the wind proved very inefficient in the transportation of pollen. Even at a distance of ten feet,—the distance of one tree from another,—and in the

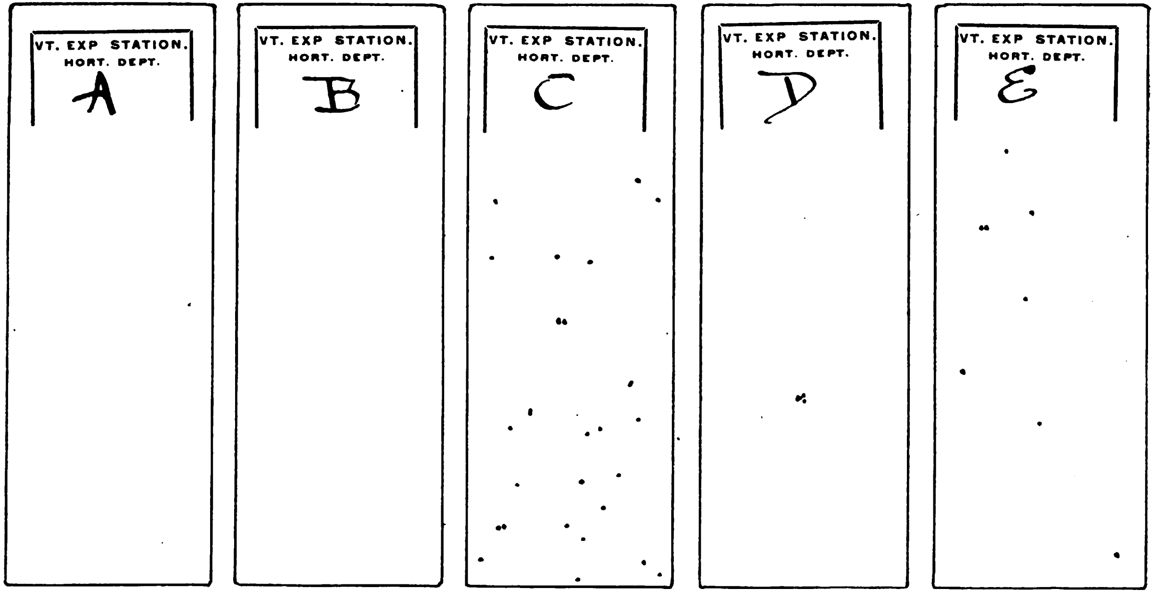

Fig. 3. RECORDS OF POLLEN TRANSFERS BY WIND

direct course of the wind, the amount of pollen transported was far too small for effective pollination, as will be seen by consulting slip C. In other cases the transfer of pollen was practically nothing, though the distances were insignificant and the conditions highly favorable.

The fact that pollen was nearly always found on the slips in masses is explained by the waxy, sticky nature of all fresh plum pollen. Such plum pollen will adhere to a smooth knife blade so strongly that it can hardly be blown off by the breath. This makes it most admirably adapted to transfer by bees, but very poorly adapted to transportation by the wind.

At the end of a hot, dry day a few grains of pollen may sometimes be found still in the blossoms; and at such times these grains are sufficiently dry to be carried by the wind with greater ease. It seems hardly probable, however, that they are of any importance in the pollination of an orchard.

Pear pollen is usually even more sticky and gummy than plum pollen. Apple pollen is a little less so. It seems from observations made by the writer, that the pollination of these fruits, also, is effected chiefly, if not exclusively, by insects, while the wind plays no consequential part. These conclusions are the same as those reached by Waite,[1] who has experimented widely in the pollination of pomaceous fruits.

THE POLLINATION OF APPLES

While the pollination of pears and plums has been somewhat exhaustively investigated, the pollination of apples, rather oddly, has been comparatively neglected. The principal work has been done by Waite, who studied apples incidentally along with his experiments in the pollination of pears. In his first publication,[2] Waite said: "The varieties of apples are more inclined to be sterile to their own pollen than the pears. With the former, in the great majority of cases, no fruit resulted from self-pollination." The same general conclusions have been reiterated in a later publication.[3]

After all that has been said and written about the pollination or fertilization of flowers of fruit trees, it will hardly be necessary to enter into a detailed explanation of the elementary facts. Nevertheless it may be best to give so much of a review as is involved in the following statements: (1) It is necessary for the pollen borne by the blossoms to fall on the stigmas (central organs) of the flowers. This is called pollination. (2) When this occurs under favorable circumstances, the substance of the pollen grains fecundates, impregnates, or fertilizes the little ovules, which are just beginning to form in the embryo apple, pear or plum. (3) Unless this fecundation of the seeds takes place, the fruit usually does not develop. It withers and falls off instead. The crop of fruit is therefore dependent on the success of this process of fecundation. (4) The flowers of many kinds of fruits, however, refuse to be fecundated with pollen from the same tree or variety. They require pollen from some other source. That is, they require cross-pollination; in which case they are said to be self-sterile.

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[1] U. S. Dept. Agr. Div. Veg. Path., Bul. 5, p. 81 (1894). See also U. S. Dept. Agr., Year-book, 1898, p. 175.

[2] U. S. Dept. Agr., Div. Veg. Path. Bul. 5, p. 81 (1894).

[3] U. S. Dep. Agr. Year-book, 1898, p. 175.

I. SELF-STERILITY

The Vermont experiment station has carried on experiments for two years with a view to determine the general extent of self-sterility in apples. These experiments have been conducted chiefly in the orchard of Mr. S. P. Gordon of Grand Isle county, who has one of the best collections of varieties in this vicinity, and to whom we are greatly indebted for many kindnesses.

The tests herewith reported were made in the same manner as our tests of the self sterility of plums[1].

Clusters of blossoms were covered with thin paper sacks, there being usually from ten to thirty blossoms in each sack. The enclosed blossoms were thus protected from the visits of bees bringing pollen from other trees, and also from any pollen which might possibly be borne by the wind. At the same time they would be freely pollinated by the pollen from the numerous blossoms enclosed. That such self-pollination actually occurred was frequently ascertained by examination with a hand lens. That the fecundation of the ovules did not occur was inferred when the fruits withered and failed to set.

After the blossoming season was passed the sacks were removed and the blossoms examined; and record was made of the fruits set, of the blossoms which had failed to set fruit, and of the crop set on the tree by those blossoms which were uncovered. The results of these tests are grouped in the following table. The figures for each individual tree are kept separately, so that the five entries under Baldwin mean that five trees were included in the experiments during the two years.

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[1] For a discussion of this method, and of the reliability of results given by it, see Vt Exp. Sta. Rpt. 11, p. 240 (1898).

RECORD OF PROTECTED APPLE BLOSSOMS

Variety	Number blossoms covered	Fruits set	Crop on tree
Baldwin	44	0	good
"	19	1	"
"	42	0	extra
"	37	0	"
"	27	0	"
Ben Davis	19	0	light
Esopus (*Spitzenburg*)	11	0	fair
"	53	1	"
"	22	0	"
Fameuse	65	1	good
"	59	0	"
"	50	0	"
"	17	0	"
"	32	0	"
Greening (*Rhode Island*)	50	0	"
"	22	0	"
"	34	0	fine
"	62	0	good
"	41	0	"
"	44	0	moderate
"	32	0	"
"	23	0	"
"	104	0	heavy
"	72	0	good
"	16	0	"
"	62	0	"
"	69	0	moderate
"	72	0	good
Hawley	53	0	light
King	15	0	fair
Northern (*Sweet*)	81	0	good
"	32	0	"
Northern Spy	19	0	light
Porter	52	0	extra
Red Astrachan	16	0	heavy
Red Canada	80	0	good
Roseau	75	0	moderate
"	45	0	fair
Roxbury (*Russet*)	27	0	moderate
"	30	0	light
"	21	0	"
"	41	0	"
Tolman (*Sweet*)	132	0	heavy
"	21	0	good
"	55	0	"
"	15	0	"
Wealthy	28	0	"
Westfield (*Seek-no further*)	58	0	"
"	37	0	moderate
"	67	0	fair
"	85	0	"
"	95	0	"
"	94	0	light
"	49	0	good
Williams (*Favorite*)	30	0	"
"	33	0	"
Totals	2586	3	

The results are very striking, only three apples having set out of the 2586 blossoms covered, or a little more than one-tenth of one percent. These were of Baldwin, Esopus, and Fameuse,—varieties generally accounted to be more or less self-fertile. The self-fertility, however, was not great enough in any case to encourage any one to depend on self-pollination for a crop of fruit.

Waite has shown also in his experiments already cited, that, even where fruit forms by self-pollination, better fruit is given by cross-pollination. So that, though it is possible that our experiments show an unusual degree of self-sterility, there is still every reason to feel that the importance of cross-pollination has not been over-emphasized.

The practical conclusion to be drawn from these experiments is simple and unequivocal. It is that *large blocks of apples of a single variety should never be planted, no matter what the variety may be. Mix two or more varieties together in alternating rows.*

II. OTHER CONSIDERATIONS

Beside the plain rule that varieties should always be mixed in orchard planting, certain other practical considerations are to be held in mind.

1. The varieties which stand next to one another should blossom at the same time; otherwise cross-pollination can not take place. One of the finest orchards of Northern Spy in Vermont is unproductive from lack of cross-pollination. Though there is a block of Greenings at one side they do not help, since they are always through blooming before the flowers of Northern Spy open.

We regret greatly that we are not able here to give some general information regarding the blossoming seasons of the leading varieties of apples. Each fruit grower can, to a certain extent, make such observations for himself; and it is strongly recommended that every man who has apple trees, and who expects to plant more, take notes of the dates of blooming.

2. There is always a question as to how the pollen is transferred from tree to tree. No direct experiments have been made on this point by this station, so far as apples are concerned; but careful field observations, the experiments on plums reported elsewhere[1], and the experiments made by Waite, all support the belief that the wind has little or nothing to do with the usual transfer of pollen, the work being done almost wholly by bees. Of these, the common domestic honeybee, according to our observations in apple orchards, is much the most important. Certain species of wild bees (*Andrena*, etc.) are often plentiful and do good service, but their work is not to be compared with that of the common bee. Many other insects,—flies, butterflies, etc.,—hover about the apple blossoms, but their work is of no importance.

The pollen of the apple blossom, when fresh, is slightly sticky, so that, while it adheres quickly to the hairy bodies of the bees and is easily transported by them from tree to tree it is not readily[2] blown about by the wind.

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[1] See page 359 of this report.

[2] See further on this point, page 362 of this report.

3. The fruit grower will understand, therefore, how practically important it is to encourage the visits of the bees. Spraying at such a time and in such a manner as to interfere with their work is the worst possible policy, even if such spraying did not do more damage than good to the trees themselves.

Further, in planting trees to secure cross-pollination, the habits of the bees are to be chiefly considered, and not the prevailing winds. Not more than three rows of any one variety should be planted together—better only one or two—with which some other variety or varieties should alternate.

THE MYROBALAN PLUMS

It has been the custom of the horticultural department of the Vermont experiment station, in its systematic study of plums, to give special attention to particular groups and to present the results of these studies, from time to time, in the form of monographs. In this way the Wayland group,[1] the Hybrid plums,[2] the Domestica plums,[3] and the Sand plums[4] have been dealt with. Notes have now accumulated which make it seem proper to attempt a brief monographic account of the Myrobalan plums.

I. HISTORICAL NOTES

The history of the Myrobalan plums was pretty well ransacked by Bailey[5] in 1892. Previous to this time various botanists, including some American writers, had attributed an American origin to the Myrobalan plum. Some early European authors, however, had believed these plums to belong to the continent of Europe. Linnæus was one of these; and he furthermore assumed it to be an offshoot of the common cultivated plum of Europe, *Prunus domestica*. This opinion was shared by many of the most acute early European botanists, and undoubtedly presents a large measure of fact, though it is now more generally held separate from that species and is given the species name *Prunus cerasifera*.

The Myrobalan plum has been known in cultivation at least since 1601, when it was described and figured by Clusius in his *Rariorum Plantarum Historia*. Since then it has been included under the name Myrobalan (or

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1 Monograph of the Wayland Group of Plums, Vt. Sta. Rpt. 11, p. 281-287 (1898). See also Gard. and For. 10, p. 350 (1897).

2 Hybrid Plums, Vt. Sta. Bul, 67 (1898); Vt. Sta. Rpt. 12, p. 218-230 (1899).

3 Types of European Plums in America, Vt. Sta. Rpt. 12, p. 210-218 (1899). Also Early Botanical Views of *Prunus domestica*, Bot. Gaz. 26, p. 417-427 (1898).

4 The Sand Plums, Country Gentleman 63, p. 68 (1898).

5 Cornell Sta. Bul. 38, p. 32 (1892).

Myrobolan) or cherry plum in nearly every botanical and pomological work touching the subject.

In America the Myrobalan plum seems to have been known from the first. Coxe speaks of the Myrobalan plum in his Cultivation of Fruit Trees, page 232, published in Philadelphia, in 1817. Prince, in his Treatise on Horticulture, New York, 1828, does not mention any plum which can be called a Myrobalan, but this can be explained by the much abridged character of the work. In the Pomological Manual, published by the same firm, New York, 1832, the American cherry plum and the European cherry plum evidently are of this group, and possibly so is the Small Mirabelle. In the first edition of Downing's Fruits and Fruit Trees of America, New York, 1845, the Cherry plum was described as a Myrobalan, as was also the Mirabelle. (The latter may possibly not be a Myrobalan.)

These references to named varieties are of no value, however, except as they show that the Myrobalan plum was here in America and was understood to be a separate thing. All the while it was propagated largely from seeds and used for stocks, so that its fruit characters were not closely scrutinized.

It was only on the appearance of the Marianna, that the interest in these plums was put upon the plane with others. This variety was introduced in 1884, from Texas, and was accorded a noisy and much unmerited boom by certain nurserymen, who succeeded in planting it in considerable orchards in various widely separated parts of the country. As an orchard fruit it proved a disappointment; but, meanwhile, various nurserymen had discovered that it grew readily from cuttings and made a good stock for the propagation of other plums, so that it continued to be extensively grown.

Marianna has been supposed to be a hybrid between the Myrobalan "and some American plum, possibly the Wildgoose;"[1] but in the view of the present writer, is rather to be rated as a Myrobolon-Chicasaw hybrid.[2] The spreading half thorny habit of the tree, the flowers borne several in a cluster, and the short stem of the fruit, are characters not common to the Myrobalan plums, but always found in the Chicasaws.

DeCaradeuc and Hattie have been similarly classed as hybrids. The former seems to me to be pure Myrobalan; and though the characters of the latter seem in some respects foreign to this type, particularly in the spreading, half thorny appearance of the tree, I can not attribute them to any definite extraneous source. The origin of Hattie is unknown.

The Pissard plum has been referred to a special botanical variety of the myrobalan species, *Prunus cerasifera pissardi*,[3] and the name has even been written in the form given to a separate species, *Prunus pissardi*.[4] In the opinion of the writer either course emphasizes too much the distinctness of the variety. It is better to be regarded merely as a purple-leaved horticultural variety of the Myrobalan group. Its most striking character is in the color of its foliage ; but foliage of similar color has appeared several times in other seedlings of Myrobalan parentage, in hybrids of Japanese parentage, and even in pure seedlings of the common Japanese plums.

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[1] L. H. Bailey, Cornell Sta. Bul. 38. p. 32 (1892).

[2] See Vt. Sta. Bul. 67, p. 23 (1898).

[3] Bailey, Field, Forest and Garden Botany, revised edition, p. 145, (1895).

[4] Carriere, Rev. Hort. 1881, p. 190.

The other varieties of this group, named and described further on, are, in the judgment of the writer, pure Myrobalan seedlings.

II. PRESENT STATUS

At present the Myrobalan plums are used chiefly, as they always have been, as stocks for budding or grafting other plums. Marianna is least of all an exception to this statement. They have many distinct advantages for this purpose, the principal advantage being their ready growth from seeds or cuttings. When stocks are grown from cuttings, as of Marianna, much greater uniformity is secured ; and this is a great gain. Myrobalan stocks are still imported in considerable quantities from France. The Myrobalan stocks have some weaknesses, however ; as, for example, they are not hardy enough in the north, and they tend to dwarf certain strong growing varieties. For this reason nurserymen are anxiously experimenting in the hope of finding something better ; and some propagators, thinking that something better has been found, have taken to Americana stocks at the north, or to peach stocks at the south.

A few varieties have been named and propagated ; but for the production of fruit they are generally undesirable. The blossoms seem to have an unusual degree of ability to withstand frost, and this gives them a certain value in regions where late spring freezes frequently destroy the plum crops. The pomological characters may be summarized as follows : Fruit round or slightly oval, small, with a slender stem; no suture; color light, transparent red or yellow, with some dots and a thin bloom; skin thin; flesh soft and watery; stone rounded, not much flattened, cling; flavor of sugar and water, quality seldom good; season early ; tree usually upright and clean, with small, oval, finely serrate, bright green leaves ; flowers appearing early, one or two at a node.

The Myrobalan plums have been used to some extent in hybridizing. Some of the hybrids show fairly satisfactory qualities, but on the whole, this is one of the less promising species for hybridization.

The following named varieties ought to be discussed in this group :

III. VARIETY NOTES

Brill.—Form spherical; size small, an inch or less in diameter ; cavity broad, shallow ; stem medium long, slender ; suture a line ; color even red ; dots invisible when fully ripe ; bloom slight ; skin thin ; flesh, yellow, soft, juicy ; stone, small, free ; flavor, sweetish ; quality, fair; season early ; tree, a handsome, upright grower.

DeCaradeuc.—Form spherical ; size medium ; cavity very shallow ; stem moderate ; suture a line ; apex, rounded ; color even red ; dots a few large yellow ; bloom thin ; skin thin ; flesh yellow, rather watery ; stone medium size, oval, rounded, cling ; flavor, sweetish but watery ; quality fair; season early, a week or so before Wildgoose ; tree a vigorous, rather upright grower. Originated with A. de Cardceuc, South Carolina, about 1850, being a seedling from some French plums.

Frostproof.—Form spherical ; size small ; suture a fine line ; color dark crimson ; dots many, minute ; bloom thin ; skin medium thick and firm ; flesh yellow, more or less streaked with red, unusually firm and meaty; stone small, smooth, cling; flavor sweet; quality good to very good; season early July in Missouri. Introduced by J. H. G. Jenkins, Spring Garden, Mo., in 1898. One of the best of this group, except for its small size. Appreciated by the introducer for the fact that the blossoms seldom suffer from late frosts.

Hattie.—Fruit round or a little elongated ; size small short ; cavity shallow ; stem slender; suture a line ; color dull metallic transparent red ; dots many, conspicuous ; bloom thin ; skin thin, tough ; flesh yellow, soft and watery ; stone medium size, rounded, cling ; quality only fair ; season early, about with De Caradenc ; tree rather dwarfish, spreading ; origin unknown.

Hogg's No. 2.—Probably the same as Marianna.

Marianna.—Fruit spherical or nearly so ; size small to medium, sometimes an inch and a half in diameter ; cavity very shallow ; stem medium ; suture a line only ; apex rounded ; color bright, transparent red ; dots several, medium large ; bloom medium; skin thin ; flesh yellow, soft and stringy ; stone rounded, smooth, turgid, cling ; flavor sweetish, like sugar and water ; quality poor to fair ; season medium early, about with Wildgoose. Originated with Charles G. Fitze, Marianna, Polk county, Texas, and introduced in 1884 by Charles N. Eley, Smith Point, Texas ; was boomed by some not-too-scrupulous nurserymen and widely sold, but is now seldom or never planted except for stocks.

Pissard.—Fruit spherical, about an inch in diameter ; cavity medium deep ; stem slender, medium long ; suture a dark line ; color dark dull red at maturity ; dots hardly visible ; bloom thin ; skin thin and tender; flesh soft, rather stringy, red ; flavor sweetish, watery ; quality fair to good ; season early ; tree a fairly vigorous grower, upright vase-form, with large healthy foliage, the leaves bright purplish red ; desirable for its foliage. The Pissard plum was named with the botanical name *Prunus pissardi* (a distinction it does not deserve), after M. Pissard, the French gardener to the Shah of Persia, who sent it to Europe about 1880. It is said to have originated at Tauris, near Teheran, in Northern Persia.[1] (See page 367).

Tarleton.—Form round; size small; cavity shallow; stem medium; suture a line; apex a dot; color even red; dots invisible when fruit is ripe; bloom thin; skin thin but firm; flesh soft, somewhat watery, yellow; stone small, cling; flavor sweetish; quality fair; season very early; tree somewhat irregular and spreading, but vigorous. This variety is much like what is known in some parts of the west under the name of Early Cherry.

Tomato.—Form spherical; size small to medium; cavity shallow; stem short, slender; suture none; color dark red; dots very minute; bloom thin; skin thin; flesh soft, yellow; stone large, oval, flattened, cling; quality poor to fair; season medium. A new variety, seedling of Pissard, originating with A. L. Bruce, Basin Springs, Tex. Not yet tested.

PLUM TREE CANKER

European horticulturists have long had to deal with various fruit tree diseases which they have grouped under the general name of canker. In this country we have had little trouble with similar diseases. The first trouble to gain any general notice under the name of canker, has been the malady of the apple tree, which has been frequently mentioned during the last two or three years.[2] The present writer has figured and described a canker of peach trees,[3] very similar to the plum tree canker herewith recorded. Selby has recorded,[4] under the name of gummosis, what seems to be the plum tree canker and the peach tree canker in their early stages. Doubtless much of the trouble mentioned in horticultural and mycological literature as gummosis[5] is really this canker. The Nectria canker of plum trees mentioned by the Duke of Bedford and S. U. Pickering[6] is probably different from that here under consideration.

The canker of plum trees. is to be distinguished from gummosis as following it and being often the result of it. Gummosis consists in the mere exudation of gum from any wound, and it frequently occurs in all the stone fruits. When wounds of peach or plum remain unhealed for some time, either as a result of the gum-flow or from any other cause, the surrounding tissues become blackened, hardened, as it were corroded, so that the usual processes of healing do not progress in the normal manner. While the surrounding parts continue to grow, the cankered portions remain dead, blackened and sunken below the adjacent green portions. In extreme cases the branch is finally killed. It is to these blackened, unhealed, unhealing spots that the term canker should be specifically applied.

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[1] See Garden and Forest 1, p. 178 (1888).

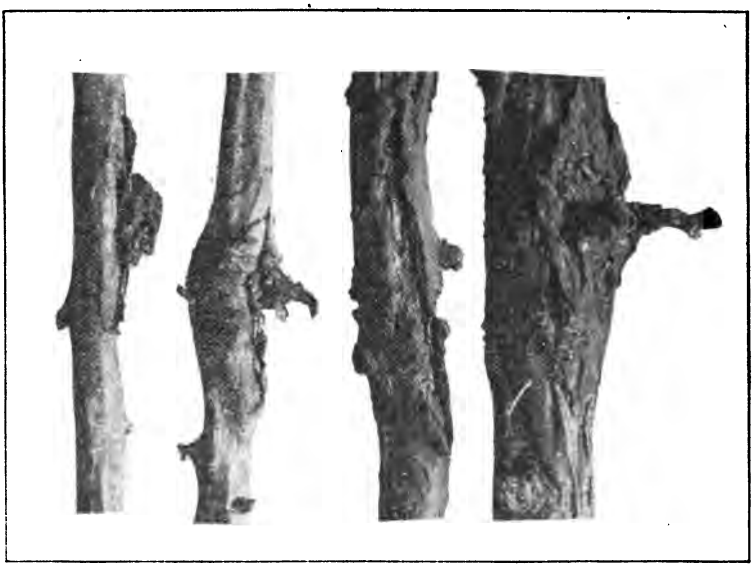
[2] See especially Paddock, N. Y. State Exp. Sta. Bul. 163 (1899).

[3] Country Gentleman 65, p. 324 (1900).

[4] Ohio Exp. Sta. Bul. 79, p. 121 (1897).

[5] See especially Beach, Am. Gard. 19, p. 606 (1898).

[6] Woburn Exp. Fruit Farm Rpt. 1897, p. 164, Exp. Sta. Rec. 9, p. 761 (1898).



PLUM TREE CANKER

This disease has been studied for three years in the field; and microscopic examinations have been made for me by Mr. M. B. Waite of the United States Department of Agriculture, and by Mr. L. R. Jones, the botanist of this station. The microscope study has not revealed the presence of any fungi or bacteria which could be called the cause of the disease; and the field observation confirms the opinion that some other origin is to be ascribed to it. It seems, rather, that when any wound occurs to a branch of a plum tree, especially to any variety which has soft, coarse-grained wood, there follows a sort of bleeding, usually running quickly into the typical gum-flow, which seriously hinders the normal formation of cambium for healing the hurt. Limbs broken or bruised by hail stones, cut by insects, pruned by the knife, broken by fruit, rubbed in crossing, or peeled by cultivator or harness, may develop canker spots at the point of injury.

In the most usual course of events, however, the trouble begins in an attack of the so-called brown fruit rot, (*Monilia fructigena*). This fungus works in the tissues, especially attacking the fruiting spurs, which are often killed outright. Usually these small dead spurs begin to exude gum and the ordinary gummosis supervenes, to be followed in turn by the more conspicuous canker spots. Sometimes, however, there is no visible gum-flow; but the dead fruit spurs stop growing (naturally) and do not heal, developing the typical cankers without the intervention of gummosis.

Next to the monilia, the most common cause of the canker, according to our observations, is the disease known as plum pockets, (*Exoascus spp.*). The pockets appear on young fruits, on leaves, and on young shoots. The worst cases are those on the shoots. When young shoots are killed back to the parent stem, wounds are left very similar to those caused by the killing of fruit spurs by the monilia. From these the canker follows in the same way. The two stems at the left in the illustration, are of Whitaker, and show the first stages of canker following the death of small shoots from pockets. The third stem from the left is Kelsey, and shows a canker of one years' standing, caused by the killing of a fruit spur by monilia. The stem at the right is Satsuma, showing a canker of two years' standing, caused also by the death of a fruit spur from monilia.

Naturally the canker is much worse on some varieties than on others, worse some seasons than others, and worse in some localities than in others. Those varieties suffer most, which are most attacked by monilia and exoascus, (the brown rot and plum pockets fungi). It is impossible to give here a list of varieties most susceptible to these diseases; but in a general way, it may be said that the Japanese and Sand plums (*Prunus augustusfolia watsoni*) are very apt to suffer severely from monilia, and the Nigra plums suffer worst from pockets. The Japanese plums succumb on account of their soft and coarse-grained, peach-like wood; and, being thus for two reasons, specially apt to be troubled with canker, are the plums which are most severely attacked. The Sand plums, though very severely attacked by monilia, do not canker readily on account of their very hard, close-grained wood. The cankers are naturally worse in years when these causative fungus diseases are most prevalent, though the canker spots are usually more conspicuous the year after. Localities which are much subject to the monilia and the exoascus are most troubled with canker. The canker has been found more or less, however, in all orchards examined, from Maryland to Vermont, though it seems to be worse in southern latitudes.

As the canker is not directly of fungus origin, but is rather one of the so-called "physiological" diseases, spraying cannot be expected to serve as a remedy. After the cankers appear, the only way to rid the tree of them is with the pruning knife. Inasmuch as they are not of fungus origin, however, they are not propagated by spores; and the removal and burning of the canker spots is not so imperative as is the removal of black knots, fruits mummied with monilia, or twigs killed by pockets.

The proper treatment of the canker, however, is evidently preventive, and consists principally in arresting the spread of the brown rot fungus (monilia) and of the pocket-making fungi; (exoascus). These diseases being of fungus origin, may be reached by spraying with bordeaux mixture, which should be applied early in the spring, before the buds start. As these diseases are more fully dealt with in other publications of this station, where the proper remedies are also prescribed, it will not be necessary to follow this part of the subject further.

REPORT OF THE CHEMISTS

C. H. JONES AND B. O. WHITE

A large portion of the time of the chemists is devoted to work the results of which find expression in publications other than the present, and under a variety of headings. Work in connection with botanical and horticultural investigations occupies a portion of the time; and likewise the analyses shown under "Dairying" are made in the chemical laboratory. Three months work has been done, as usual, on commercial fertilizers, and is reported in bulletins 77, 79 and 80, referred to on page 266 of this report. The analytical work connected with the feeding stuffs inspection consumed about a month and a half of time, (see bulletins 78 and 82.)

It may be here noted that several investigations are not complete enough to render them available for publication at this time. Among them may be mentioned the determination of the constituents of the nitrogen-free extract matter in artichokes and potatoes sampled at different stages of their growth. Data relating to maple sap flow and composition, the latter including the analyses of several hundred samples of sap, have been compiled, the work of previous years in this line being continued.

The matter presented in this report will be discussed under the following heads:

Composition of potatoes at various stages of growth:
I. Crop of 1898.
I. Crop of 1899.
Composition of the artichoke plant and tuber at various stages of growth.
Miscellaneous analyses.

COMPOSITION OF POTATOES AT VARIOUS STAGES OF GROWTH

General outline of the work.—During 1898 and 1899 the botanical department of the station instituted a series of experiments with potatoes which included study of diseases, of the effects of spraying, and of the time and rate of the development of the tuber.[1]

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[1] Vt. Sta. Rpts. 12, pp. 151-156 (1899); 13, pp. 269-281 (1900).

Experiments of 1898.—Two standard varieties, White Star and Delaware, were used. The seed was planted May 16, 1898 on a rather heavy clay soil. Some 75 rows were included in the experimental plot. Digging was begun August 4, every ninth row being then dug. This was similarly continued at more or less regular intervals of ten days, until October 3. The final harvesting took place November 3. The tubers dug at the sundry dates were sorted into marketable and small tubers, and three six-pound samples of the former, of each variety, and two of the latter, taken. These were prepared for analysis, by suitably cleaning, carefully slicing, stringing on copper wire and drying at a low temperature. One composite sample of each variety and size, for each data, was then made, which served for analysis.

Experiments of 1899.—The Delaware variety only was used in 1899. The two experimental plots contained 21 rows each of this variety, and, as before, samples were taken in triplicate of both the marketable and the small tubers. Sampling began August 12, and ended October 11. On the first sampling date, rows 1–8–15 of each plot were used; on the second date, rows 2–9–16, etc. In the preparation at the laboratory, composites were made from equal weights of samples from corresponding rows of the two plots. Thus No. 1, for crop of 1899, contained equal parts by weight of Delawares from the first row of each plot. During both seasons the several plots were treated with paris green and bordeaux mixture as occasion required.

Object of the work.—The object was two-fold: (1) to see to what extent, if any, chemical differences in minor ingredients existed in marketable and small tubers dug at various stages of growth; and (2) to determine the composition of the so-termed nitrogen-free extract matter. The latter work is, as heretofore stated, yet incomplete.

I. CROP OF 1898

The following table gives the analyses of 32 composites, 80 single samples being used in their makeup. These figures, it is believed, may safely be taken to represent the composition of the varieties grown at the given dates.

SET 1. VARIETY, WHITE STAR. MARKETABLE

Number	Date of digging	Original substance		Composition of dry matter							
		Water	Dry matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Nitrogen	Phosphoric acid	Potash
1	August 4, 1898	81.88	18.12	7.04	10.57	2.34	79.61	0.44	1.690	0.505	3.028
5	August 15, 1898	82.16	17.84	6.85	10.41	1.76	80.54	0.44	1.665	0.562	3.473
9	August 24, 1898	80.60	19.40	7.00	10.52	1.67	80.28	0.53	1.683	0.736	2.897
13	Sept. 3, 1898	82.16	17.84	6.77	10.59	2.19	80.06	0.39	1.694	0.516	2.973
17	Sept. 13, 1898	81.74	18.26	6.79	10.48	2.22	80.23	0.28	1.677	0.622	3.354
21	Sept. 26, 1898	81.33	18.67	7.00	11.39	2.28	78.89	0.44	1.822	0.619	2.960
25	Oct. 3, 1898	81.76	18.24	7.09	11.18	2.18	79.11	0.44	1.789	0.567	2.911
29	Nov. 3, 1898	81.48	18.52	7.20	11.12	2.11	78.93	0.64	1.780	0.542	2.874
	Average	81.64	18.36	6.97	10.78	2.09	79.71	0.45	1.725	0.584	3.058

SET 2. VARIETY, DELAWARE. MARKETABLE

2	August 4, 1898	78.95	21.05	6.63	10.57	1.74	80.53	0.53	1.690	0.505	2.745
6	August 15, 1898	79.36	20.64	6.47	10.65	1.55	80.64	0.69	1.703	0.641	2.908
10	August 24, 1898	79.08	20.92	6.64	11.18	1.33	80.27	0.58	1.790	0.623	3.213
14	Sept. 3, 1898	80.51	19.49	6.42	11.18	1.72	80.40	0.28	1.789	0.567	2.889
18	Sept. 13, 1898	80.01	19.99	6.65	11.63	1.75	79.36	0.61	1.861	0.798	3.036
22	Sept. 26, 1898	79.40	20.60	6.73	11.55	1.81	79.38	0.53	1.849	0.617	2.752
26	Oct. 3, 1898	80.22	19.78	6.69	11.59	1.81	79.52	0.39	1.854	0.563	2.815
30	Nov. 3, 1898	80.35	19.65	6.49	11.62	2.05	79.40	0.44	1.858	0.509	2.755
	Average	79.73	20.27	6.57	11.25	1.72	79.95	0.51	1.800	0.603	2.889

SET 3. VARIETY, WHITE STAR. SMALL

3	August 4, 1898	81.84	18.16	7.22	9.92	2.20	80.03	0.63	1.588	0.617	2.933
7	August 15, 1898	79.79	20.21	6.45	10.45	1.61	81.01	0.48	1.672	0.676	3.057
11	August 24, 1898	80.41	19.59	6.97	10.55	2.12	79.88	0.48	1.687	0.570	2.883
15	Sept. 3, 1898	81.80	18.20	6.89	10.59	2.24	79.75	0.53	1.694	0.628	2.950
19	Sept. 13, 1898	81.94	18.06	7.14	10.50	2.22	79.44	0.70	1.679	0.912	2.668
23	Sept. 26, 1898	82.49	17.51	7.31	11.21	2.46	78.41	0.61	1.794	0.624	2.964
27	Oct. 3, 1898	83.73	16.27	7.23	11.18	2.15	79.02	0.42	1.790	0.567	2.824
31	Nov. 3, 1898	82.31	17.69	7.37	11.00	2.24	78.89	0.50	1.760	0.568	2.862
	Average	81.78	18.22	7.07	10.68	2.16	79.85	0.54	1.709	0.645	2.893

SET 4. VARIETY, DELAWARE. SMALL

4	August 4, 1898	79.12	20.88	6.47	9.92	1.93	81.18	0.50	1.588	0.728	3.043
8	August 15, 1898	81.72	18.28	7.16	9.96	2.32	80.01	0.55	1.594	0.742	2.877
12	August 24, 1898	79.15	20.85	6.17	9.72	1.70	81.58	0.83	1.556	0.622	2.911
16	Sept. 3, 1898	81.09	18.91	6.46	10.97	1.62	80.43	0.52	1.754	0.677	2.875
20	Sept. 13, 1898	80.76	19.24	6.81	10.92	1.99	79.64	0.64	1.746	0.906	3.006
24	Sept. 26, 1898	80.40	19.60	6.80	10.42	1.93	80.19	0.66	1.667	0.629	2.881
28	Oct. 3, 1898	81.98	18.02	6.71	10.45	1.83	80.68	0.33	1.672	0.509	2.790
32	Nov. 3, 1898	82.07	17.93	7.10	11.46	1.87	79.07	0.50	1.833	0.544	2.800
	Average	80.79	19.21	6.71	10.48	1.90	80.34	0.57	1.677	0.670	2.898

Discussion of results.—A comparison of the individual analyses, as well as the averages, shows that quite marked differences in composition exist between the two varieties. Thus taking the average of sets 1 and 2, we find that the Delawares contain 1.91 percent more dry matter, 0.47 percent more protein, 0.40 percent less ash, and 0.37 percent less fiber. Differences in the same direction are observed without exception in the individual samples. The ether extract varies from 0.28 to 0.69 percent, but the averages show only slight differences. Of the ash constituents determined, the phosphoric acid and potash are practically similar in each case. The greatest variation in the nitrogen free extract matter is only 1.75 percent. Under this head is included for the main part, starch, which, with the water, forms some 95 percent of the original potato.

Turning to the small tubers, sets 3 and 4, we again find more dry matter in the Delawares although the variation is not so large, being only one percent. With the samples taken August 15, however, the reverse is true, as the White Star on that date had nearly two percent more dry matter than did the Delaware. This is also the case with the average protein content, the percentage in the Delawares being slightly less than with the other. Aside from this the variations in composition are similar to those noticed with the marketable tubers.

Variations between samples of each set dug at different dates are not pronounced. Aside from the rather gradual gain in protein, the differences in other estimated constituents are irregular.

Summary, 1898.—The dry matter was the greater in the Delawares and the general tendency was to decrease as the season advanced.

The protein content in both varieties, with but few exceptions, gradually increased with the advance of the season. The greater amount was present in the Delawares.

The ash in marketable tubers was quite constant in its proportion throughout the season. Its percentage was greater with the White Stars. With the small tubers its tendency to vary was more marked.

Crude fiber, considering the small amount present, was very variable. The extremes in the different sets were 1.67 to 2.34 percent, 1.33 to 2.05 percent, 1.61 to 2.46 percent and 1.62 to 2.32 percent respectively.

The ether extract in the several sets ranged from 0.28 to 0.64, 0.28 to 0.69, 0.42 to 0.70 and 0.33 to 0.83 percent.

The average phosphoric acid content was greater in the small potatoes by 0.06 percent than in the large tubers; the difference between the varieties was but a few hundredths of one percent.

Potash was found to be in slightly larger proportions in the White Star than in the Delaware.

The nitrogen-free extract figures were very uniform, the amount slightly favoring the Delawares. Its composition, particularly as regards the starch content, will be shown in a future publication.

The Delawares proved far more palatable and desirable for table use than did the White Stars. It is doubtful if any of the differences noted in composition can wholly explain this fact. Season, soil, and varietal differences may have an important bearing in the matter.

Yield.—The yield in bushels to an acre on the different dates of digging is shown in the table below.

Date	Total yield	Marketable	Small
Aug. 4, 1898	92	65	27
" 15, "	99	76	23
" 24, "	116	88	28
Sept. 3, "	153	130	23
" 13, "	172	152	20
" 26, "	197	181	16
Oct. 6, "	226	290	17

It is perfectly clear that the marked differences observed in the potato crop as maturity advances affect the yield rather than the composition. In 1898, owing to drought during July and early August, more than one half of the development occurred after Sept. 1.

All the plots were sprayed during the season with bordeaux mixture and paris green. The yield of marketable tubers on the unsprayed plots was 112 bushels an acre, and records show that the vines were practically dead by Aug. 20. This premature death, therefore, due to lack of proper treatment, resulted in serious loss through failure of the tubers to mature properly.

A single sample of Delawares (marketable and small) from the unsprayed plots was taken Nov. 3. The vines were dead August 15. The analysis follows.

ANALYSIS OF DELAWARE POTATOES, UNSPRAYED PLOTS

	Marketable	Small
Water	81.33	81.22
Dry matter	18.67	18.78
	100.00	100.00

COMPOSITION OF DRY MATTER

	Marketable	Small
Crude ash	7.32	7.52
Crude protein	11.22	10.26
Crude fiber	1.67	1.97
Nitrogen-free extract	79.35	79 83
Ether extract	0.44	0.42
	100.00	100.00
Nitrogen	1.796	1.642
Phosphoric acid	0.569	0.625
Potash	2.711	2.971

While much stress cannot be laid on these single analyses as representing the average composition of tubers on unsprayed plots, yet it is interesting to note the increase in moisture and the corresponding decrease in dry matter content as compared with the same variety on sprayed plots where growth continued for several weeks later. The ash percentage likewise shows a decided increase.

II. CROP OF 1899

The following tables give the analyses of twenty-one samples each of marketable and small potatoes, from the crop of 1899, with averages for each sampling date and for the year.

TABLE I. VARIETY DELAWARE ; MARKETABLE

Date of digging	Row	Original substance		Composition of dry matter							
		Water	Dry matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Nitrogen	Phosphoric acid	Potash
August 12, 1899	1 a & b	78.97	21.03	6.21	10.68	1.62	81.17	0.32	1.708	0.487	3.157
August 12, 1899	8 "	79.02	20.98	6.01	10.48	2.01	81.17	0.33	1.676	0.457	2.993
August 12, 1899	15 "	78.08	21.92	5.90	10.45	1.74	81.56	0.35	1.672	0.445	3.018
August 22, 1899	2 "	77.09	22.91	5.60	10.77	1.57	81.76	0.30	1.723	0.471	2.869
August 22, 1899	9 "	77.00	23.00	5.67	11.06	1.21	81.85	0.21	1.770	0.432	2.909
August 22, 1899	16 "	77.60	22.40	6.08	10.60	1.69	81.34	0.29	1.697	0.453	3.120
September 1, 1899	3 "	79.67	20.33	6.09	11.20	1.85	80.56	0 30	1.793	0.470	2.967
September 1, 1899	10 "	80.80	19.20	6.52	10.68	1.89	80.67	0.24	1.709	0.531	3.026
September 1. 1899	17 "	80.79	19.21	5.96	10.64	1.59	81.46	0.35	1.703	0.465	2.940
September 11, 1899	4 "	80.51	19.49	6.56	11.24	1.80	80.15	0.25	1.799	0.534	3.205
September 11, 1899	11 "	79.27	20.73	5.73	10.74	1.63	81.53	0.37	1.718	0.446	2.815
September 11, 1899	18 "	80.40	19 60	6.14	10.84	1.62	81.15	0.25	1.735	0.496	2.867
September 21, 1899	5 "	78.88	21.12	6.33	11.38	1.95	80.01	0.33	1 821	0.390	2.872
September 21, 1899	12 "	79.23	20.77	6.20	11.01	1.73	80.77	0.29	1.763	0.493	2.868
September 21, 1899	19 "	80.08	19.92	6.42	11.65	2.11	79.55	0.27	1.865	0.542	3.047
September 30, 1899	6 "	81.13	18.87	6.38	11.65	2.00	79.72	0.25	1.864	0.531	3.175
September 30, 1899	13 "	79.60	20.40	6.48	11.37	1.82	80.03	0.30	1.819	0.520	2.967
September 30, 1899	20 "	80.75	19.25	6.14	11.24	1.61	80.71	0.30	1.798	0.503	3.103
October 11, 1899	7 "	79.03	20.97	6.02	11.31	1.78	80.60	0.29	1.809	0.442	2.811
October 11, 1899	14 "	79.53	20.47	5.97	11.30	1.88	80.58	0.27	1.808	0.398	2.819
October 11, 1899	21 "	80.13	19.87	6 32	12.13	1.84	79.50	0.21	1.940	0.544	2.963

VARIETY DELAWARE ; SMALL

Date of digging		Row	Original substance		Composition of dry matter							
			Water	Dry matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Nitrogen	Phosphoric acid	Potash
August	12, 1899	1 a & b	79.47	20.53	6.16	11.59	1.82	80.08	0.35	1.854	0.488	3.116
August	12, 1899	8 "	79.46	20.54	6.39	11.47	1.85	80.04	0.25	1.835	0.480	3.200
August	12, 1899	15 "	77.55	22.45	5.77	10.43	1.62	81.75	0.43	1.668	0.466	2.815
August	22, 1899	2 "	78.11	21.89	5.97	11.21	1.76	80.76	0.30	1.793	0.480	3.010
August	22, 1899	9 "	77.95	22.05	6.15	11.95	1.82	79.65	0.43	1.912	0.491	2.948
August	22, 1899	16 "	78.03	21.97	6.27	11.63	2.13	79.61	0.36	1.860	0.422	3.029
September	1, 1899	3 "	80.45	19.55	6.54	11.77	1.81	79.61	0.27	1.883	0.517	3.088
September	1, 1899	10 "	80.90	19.10	6.18	11.79	1.83	79.82	0.38	1.884	0.506	3.069
September	1, 1899	17 "	79.76	20.24	6.42	11.54	2.07	79.62	0.35	1.846	0.494	2.899
September	11, 1899	4 "	81.04	18.96	6.78	12.45	1.98	78.52	0.27	1.991	0.536	3.195
September	11, 1899	11 "	80.24	19.76	6.19	12.41	1.78	79.18	0.44	1.985	0.524	3.032
September	11, 1899	18 "	81.67	18.33	6.35	11.71	2.21	79.32	0.41	1.873	0.512	2.951
September	21, 1899	5 "	79.96	20.04	7.24	11.92	1.80	78.63	0.41	1.907	0.512	3.215
September	21, 1899	12 "	78.92	21.08	6.22	11.85	1.71	79.81	0.41	1.896	0.531	2.785
September	21, 1899	19 "	80.38	19.62	6.62	11.16	2.22	79.62	0.38	1.786	0.552	3.063
September	30, 1899	6 "	80.95	19.05	6.45	11.86	2.07	79.26	0.36	1.897	0.520	3.100
September	30, 1899	13 "	80.52	19.48	6.34	11.52	2.08	79.68	0.38	1.842	0.536	3.021
September	30, 1899	20 "	79.92	20.08	6.37	11.95	1.90	79.37	0.41	1.911	0.502	3.000
October	11, 1899	7 "	80.49	19.51	7.23	11.80	2.08	78.59	0.30	1.888	0.540	3.118
October	11, 1899	14 "	80.16	19.84	6.77	11.63	1.93	79.13	0.54	1.860	0.498	3.136
October	11, 1899	21 "	80.67	19.33	7.18	12.18	2.15	78.16	0.33	1.949	0.545	3.201

TABLE II. AVERAGES FOR EACH SAMPLING DATE, MARKETABLE

Date		Original substance		Composition of dry matter							
		Moisture	Dry matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Nitrogen	Phosphoric acid	Potash
August	12. 1899	78.69	21.31	6.04	10.53	1.79	81.31	0.33	1.686	0.463	3.056
August	22, 1899	77.23	22.77	5.78	10.81	1.49	81.65	0.27	1.729	0.452	2.966
September	1, 1899	80.42	19.58	6.19	10.84	1.78	80.90	9.29	1.734	0.488	2.978
September	11, 1899	80.06	19.94	6.14	10.94	1.68	80.95	0.29	1.750	0.492	2.962
September	21. 1899	79.40	20.60	6.32	11.35	1.93	80.11	0.29	1.816	0.475	2.929
September	30, 1899	80.49	19.51	6.33	11.42	1.81	80.16	0.28	1.827	0.518	3.082
October	11, 1899	79.56	20.44	6.10	11.58	1.83	80.23	0.26	1.853	0.461	2.864

AVERAGE FOR EACH SAMPLING DATE, SMALL

August	12, 1899	78.86	21.14	6.11	11.16	1.76	80.63	0.34	1.785	0.471	3.043
August	22, 1899	78.03	21.97	6.13	11.60	1.91	80.00	0.36	1.856	0.464	2.999
September	1, 1899	80.37	19.63	6.38	11.70	1.91	79.68	0.33	1.874	0.506	3.019
September	11, 1899	80.98	19.02	6.44	12.19	1.99	79.01	0.37	1.950	0.524	3.059
September	21, 1899	79.76	20.24	6.69	11.64	1.91	79.36	0.40	1.862	0.532	3.041
September	30, 1899	80.46	19.54	6.39	11.78	2.02	79.43	0.38	1.885	0.519	3.041
October	11, 1899	80.44	19.56	7.06	11.87	2.05	78.63	0.39	1.899	0.528	3.152

TABLE III. AVERAGE COMPOSITION FOR THE SEASON

Marketable	79.41	20.59	6.13	11.07	1.76	80.75	0.29	1.771	0.479	2.977
Small	79.84	20.16	6.46	11.71	1.93	79.53	0.37	1.874	0.507	3.047

Discussion of results.—It is to be noted that each single analysis in table I represents a sample taken from similar rows in two different plots, the combination being made at the laboratory. Three samples of this nature from as many rows were taken on each sampling date. Each average analysis in table II represents six different rows of potatoes in as many portions of the experimental field. By this means we endeavored to reduce to a minimum the errors which inevitably pertain to field sampling and to imperfect analytical methods, so that the average would truthfully represent the character of the crop.

Differences in the several analyses on each date invariably exist, but when the results are averaged, as in table II, more uniformity is seen, and variations, however marked between samples, become more gradual, and very generally tend in certain directions as the season progresses.

Taking the averages in table II as representing the composition at each period of development, we find that, with marketable tubers, the dry matter varied from 22.77 to 19.51 per cent, being the highest August 22 and lowest September 30, the tendency being to decrease as the season advances. The average for the season was 20.59 percent.

The extreme variation in nitrogen-free extract, which, as previously pointed out, is largely starch, was 1.54 percent, the average being 80.75 per cent, and, like the dry matter, it lessens as the growing season lengthens.

Protein on the contrary shows a steady increase in amount, from 10.53 percent on Aug. 12 to 11.58 percent on Oct. 11, with an average of 11.07.

Ash varies from 5.78 to 6.33 percent, and the average is 6.13.

Crude fiber, phosphoric acid and potash show no pronounced differences during the season. The former, however, tends slightly to increase.

Either extract remains constant.

With the small tubers the variations in composition tend in similar directions; dry matter and nitrogen-free extract decreases, and protein, ash and fiber, increase as the season advances. The ether extract remains constant, although slightly higher in amount than in the large tubers. In 1899 the average protein content of the small potatoes ran higher than with the others. With the same variety in 1898 the reverse was true.

Yield—The yields expressed in bushels to an acre for 1899 are summarized below.

Date.	Total yield.	Marketable.	Small.
Aug. 12, 1899	154	118	36
" 22,	170	126	44
Sept. 1,	254	228	26
" 11,	259	212	47
" 21,	330	291	39
" 30,	366	314	52
Oct. 11,	350	312	38

No marked increase in yield occurred after Sept. 21. Maturity had evidently been reached. The crop had been treated in the early summer with paris green to prevent ravages by insects, and was sprayed with bordeau mixture July 22, Aug. 11 and Sept. 7. This kept the vines in a healthy condition well into the fall, many being alive at the time of final harvesting October 19.

On the unsprayed portions of the same field the vines began to decline Aug. 17 and were practically dead Sept. 1.

The final yield of marketable tubers from the unsprayed section was only 223 bushels an acre, while that from the sprayed portion was 313 bushels. In other words, the plants in unsprayed rows were dead and development had consequently ceased some three weeks before the marked gain of the middle of September occurred. Three applications of bordeau mixture were therefore directly responsible for a gain of 90 bushels an acre.

Summary.—In general, it may be said that in these trials, the percentage of dry matter and nitrogen free extract in the potato tuber decreased, while that of protein, ash and crude fiber increased as the crop approached maturity. Differences in ether extract, phosphoric acid and potash are slight and show no general trend. This is in accord with results secured the previous year. As was pointed out in the work of 1898, the important variations in potatoes, dug at intervals throughout the growing season, are in the amounts yielded rather than in chemical composition.

COMPOSITION OF ARTICHOKES

During the season of 1898 a crop of "Improved french white artichokes"[1] was grown for use in feeding experiments. Measurements as to rate of growth of the tops were made from time to time and samples of both tops and tubers were taken at intervals of about ten days, beginning Aug 4.

Artichokes (*Helianthus tuberosus*) belong to the well known family of Compositae, which includes the common sunflower, dandelion, dahlia, etc. It being a crop comparatively new to this section, it was deemed of interest to note its chemical composition at different stages of growth.

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1. See St. Sta. Rep. 12, p. 282 (1899).

Sampling.—The experiment field contained 30 rows. Plants were taken from every third row on each sampling date. After removing the tubers, the tops were cut in a hay cutter, mixed, and duplicate samples taken, up to and including October 29. The tops were cut about November 1, and stooked out of doors. The samples under date of November 4, were from the several piles, No. 19, representing three, and No. 20, two separate samples.

The tubers on August 4, the first sampling date, had just begun to form and were, therefore, very small.

The table below gives the height in inches, of the tops on the dates indicated. Each figure is the average of six measurements taken through the row.

Row	Aug. 4	Aug. 15	Aug. 25	Sept. 3	Sept. 13	Sept. 26	Oct. 6	Oct. 20	Oct. 29
3	35	38	50	52	68	66	60	71	69
6	38	43	47	56	67	71	75	72	67
9	36	42	46	60	68	76	74	71	72
12	35	47	46	52	66	74	73	76	75
15	32	45	45	53	70	70	72	70	72
18	34	37	48	53	60	70	68	68	64
21	36	38	47	52	67	61	65	66	66
24	30	43	51	52	62	69	60	65	71
27	36	46	52	53	66	66	70	70	70
30	34	48	51	58	72	74	73	76	71
Average,	35	42	48	54	67	70	69	71	70

Full growth had practically been reached September 26.

The composition of the several samples taken is shown in the following tables:

TABLE I. COMPOSITION OF ARTICHOKE TOPS

Number	Sampled	Original substance		Composition of dry matter							
		Water	Dry matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Nitrogen	Phosphoric acid	Potash
1	August 4, 1898	76.86	23.14	13.82	14.17	20.39	49.92	1.70	2.268	0.650	2.630
2	August 4, 1898	77.26	22.74	14.03	12.37	21.37	50.85	1.38	1.979	0.553	2.543
3	August 15, 1898	74.74	25.26	13.13	11.62	19.83	54.08	1.34	1.860	0.513	2.245
4	August 15, 1898	74.53	25.47	15.11	11.21	18.22	54.13	1.33	1.793	0.333	2.164
5	August 25, 1898	72.87	27.13	16.10	9.88	18.70	53.91	1.41	1.580	0.433	1.883
6	August 25, 1898	73.77	26.23	16.24	10.37	17.96	53.86	1.57	1.660	0.500	1.997
7	Sept. 3, 1898	73.52	26.48	15.47	9.58	18.75	55.20	1.00	1.533	0.536	1.779
8	Sept. 3, 1898	74.00	26.00	15.40	10.68	19.46	53.38	1.08	1.708	0.497	2.032
9	Sept. 13, 1898	70.97	29.03	18.85	8.51	18.63	52.55	1.46	1.361	0.551	1.134
10	Sept. 13, 1898	72.93	27.07	19.23	9.78	18.72	50.93	1.34	1.564	0.493	2.014
11	Sept. 26, 1898	65.67	34.33	23.10	7.21	17.50	50.92	1.27	1.154	0.392	1.281
12	Sept. 26, 1898	66.60	33.40	23.97	7.70	17.59	49.46	1.28	1.231	0.353	1.370
13	October 6, 1898	65.59	34.41	24.37	7.21	18.55	48.80	1.07	1.153	0.491	1.217
14	October 6, 1898	67.73	32.27	23.75	7.73	18.02	49.21	1.79	1.236	0.355	1.376
15	October 20, 1898	65.95	34.05	27.66	6.62	20.35	44.13	1.24	1.058	0.389	1.306
16	October 20, 1898	65.10	34.90	27.96	6.01	20.03	44.84	1.16	0.962	0.275	1.247
17	October 29. 1898	64.51	35.49	25.00	5.27	24.30	44.10	1.33	0.843	0.295	1.328
18	October 29, 1898	68.72	31.28	24.10	5.72	24.93	44.07	1.18	0.915	0.237	1.249
19	November 4, 1898	62.47	37.55	10.99	6.63	31.01	49.75	1.62	1.059	0.303	1.665
20	November 4, 1898	61.30	38.70	10.98	7.26	28.46	51.31	1.99	1.162	0.247	2.023

TABLE II. ARTICHOKES

Number	Sampled	Original substance		Composition of dry matter							
		Water	Dry matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Nitrogen	Phosphoric acid	Potash
1	August 4, 1898	79.17	20.83	8.23	8.82	5.54	76.15	1.26	1.410	1.030	3.089
2	August 15, 1898	79.95	20.05	7.51	8.09	4.00	79.45	0.95	1.295	0.725	2.936
3	August 25, 1898	79.64	20.36	9.22	8.57	4.14	77.20	0.87	1.371	0.769	2.966
4	Sept. 3, 1898	81.98	18.02	7.92	9.78	4.52	76.94	0.84	1.564	0.672	3.007
5	Sept. 13, 1898	81.34	18.66	8.19	9.21	4.54	77.34	0.72	1.474	0.754	3.158
6	Sept. 26, 1898	81.67	18.33	8.34	8.21	3.45	79.54	0.46	1.312	0.563	2.989
7	October 6, 1898	81.69	18.31	7.14	8.14	3.92	80.25	0.55	1.302	0.624	2.648
8	October 20, 1898	79.53	20.47	12.10	8.06	3.85	75.64	0.35	1.290	0.575	3.439
9	October 29, 1898	79.52	20.48	13.70	9.01	4.62	72.32	0.35	1.442	0.694	2.505
10	Nov. 9, 1898	78.72	21.28	7.44	9.49	3.59	78.82	0.66	1.518	0.705	2.565
11	Nov. 10, 1898	77.56	22.44	6.53	9.89	3.69	79.65	0.24	1.582	0.689	.637
12	Nov. 16, 1898	79.63	20.37	6.98	9.83	3.65	79.27	0.27	1.572	0.845	2.674
13	Nov. 17, 1898	81.60	18.40	7.98	11.37	3.63	76.62	0.40	1.820	0.661	2.730
14	Nov. 17, 1898	79.76	20.24	7.35	12.10	3.44	76.66	0.45	1.935	0.656	2.678
15	Nov. 17, 1898	80.29	19.71	8.00	9.80	3.71	78.12	0.37	1.568	0.544	2.581
Average of last six samples		79.59	20.41	7.38	10.41	3.62	78.19	0.40	1.666	0.683	2.644

Discussion of results.—Artichoke tops: The surprising increase in ash percentage of the tops, 13.82 to 27.96, followed by a sudden drop to 10.99 percent between Oct. 29 and Nov. 4, presents an unexpected condition of things and likewise one which we are unable to explain satisfactorily. It is but fair to say that as no such condition could be foreseen, the matter was not as closely looked into at the time as it otherwise would have been.

The person having the sampling in charge reported a "dusty look" to the plants, but this was due doubtless to the fine spines which cover both the upper and lower surfaces of the leaf. In sampling, the earth was suitably loosened and the entire plant removed. The tubers were detached and the tops, as before stated, were run through a hay cutter and thoroughly mixed before duplicate samples were secured.

It was at first thought that had a heavy rain occurred after the tops were cut Nov. 1 and before the sampling Nov. 4, adhering dust would have been washed off. The local weather observer reports, however, that no rain fell from the time of cutting until several days after our samples were taken.

Watts, in his dictionary of chemistry, Vol. 1, page 413, gives the percentage of ash, on a dry matter basis, in the artichoke plant, as follows: root*12.2 percent, stem 4.4 percent, leaves 28.3 percent. The samples in which the marked decrease in ash is noted were taken, it should be remembered, some four days after the tops had been cut, bundled and stooked. As this operation would necessarily result in a serious loss of leaves, it will in part explain the lower ash percentage. A further examination shows the percentage of ash, insoluble in hydrochloric acid, to be as follows:

No. 1	2.80	percent.	No. 6	6.73	percent.	No. 11	14.50	percent.	No. 16	18.21	percent.
" 2	2.87	"	" 7	5.57	"	" 12	13.65	"	" 17	10,80	"
" 3	3.67	"	" 8	5.41	"	" 13	15.35	"	" 18	13.25	"
" 4	4.61	"	" 9	9.77	"	" 14	12.52	"	" 19	2.43	"
" 5	6,48	"	" 10	10.08	"	" 15	17.38	"	" 20	2.10	"

How much of this insoluble ash rightly belongs to the plant, it is impossible to say, and if adhering soil is included, the percentage of the other ingredients determined correspondingly vary, notably protein and crude fiber. Allowing, however, for such possible addition of insoluble ash, it can be seen that the percentages of protein, phosphoric acid and potash decrease in amount as the plant matures.

Crude fiber remains quite constant up to Oct. 6. From then on it increases.

Ether extract shows no decided tendency to rise or lower during the season. It is probable that other extractive matter than true fat is largely included under this heading.

The dry matter, as is to be expected, shows a gradual increase.

Variations between duplicate samples taken on similar dates are particularly noticeable in dry matter, protein, ether extract, phosphoric acid and potash, and re-affirm conclusions previously drawn[1] that in sampling materials of this kind a large number of samples should be taken so that an average of the results obtained will more correctly represent the composition than could the analysis of a single sample.

Artichokes.—A review of the figures given in Table II shows that variations in composition occurred during the season. These are quite marked, in protein, crude fiber and ether extract.

The protein content exhibits no constant change until after Oct. 29. The tops were harvested Nov. 1, as was previously stated, and all samples of tubers taken after that date show an increased percentage of protein as well as surprising variations in this constituent. Thus it ranges in the different samples taken Nov. 17 from 9.80 to 12.10 percent.

Crude fiber and ether extract tend to decrease as the season advances. The same is true of the ash constituents, phosphoric acid and potash, particularly the former.

Crude ash diminishes slightly. The figures under this head in samples collected Oct. 20 and 29 are not included, as, through a misunderstanding in the laboratory, the samples on these dates were not properly cleaned.

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[1] Vt. Exp. Sta. Rpt. 11, pg. 155-159. 1897.

Dry matter shows no constant variation in any one direction. The average in August was 20.40 percent, from Sept. 3 to Oct. 6, 18.48 percent, Oct. 20 and 29, 20.48 percent, and in Nov. 20.41 percent. In November an extreme variation of 4.04 percent was observed between samples No. 11 and 13.

The average composition of the artichokes when harvested, can probably best be obtained by averaging the last six samples which were all taken from various parts of the field as the crop was dug.

On comparison we find that the dry matter is about the same in artichokes as in potatoes, protein and nitrogen-free extract being less, and ash, crude fiber and ether extract, more. The main differences in composition are to be found in the constituents of the nitrogen-free extract. With potatoes, as is well known, this is largely starch, but the artichoke, in common with many compositæ, does not store starch, but in its place is a substance termed inulin. Chemically inulin is similar in composition to starch, although unlike starch it is somewhat soluble in water, is unaffected by diastasic action, and gives lævulose instead of glucose on inversion with dilute acids. It likewise, when treated with iodin solution, turns yellow in distinction from the characteristic blue of the starch grain. Associated with the inulin we find reducing sugars and relatively large amounts of a sugar to which the name synanthrose[1] has been given.

MISCELLANEOUS ANALYSES

Section 263 of the Vermont Statutes requires the station to analyze without charge miscellaneous materials of an agricultural nature for residents of the State. Such as it seems desirable to place on permanent record are here recorded.

MATERIALS FURNISHING NITROGEN

Material	From	Percent nitrogen
Nitrate of soda	Burlington	16.04
" " "	E. Montpelier	15.66
" " "	Woodstock	16.04
Dried blood	Woodstock	9.59
Cottonseed meal	Burlington	7.18

All three of the nitrates are well up in nitrogen content, 15.5 to 16 percent being usually guaranteed. The dried blood is of the low grade class, higher grades containing from 12 to 14 percent. The dried blood sold for $34 a ton and the price of a pound of nitrogen was 17.7 cents. The cotton seed meal is of good quality.

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[1] Allen Com. Org. Anal., p. 249. (1898).

MATERIALS FURNISHING NITROGEN AND PHOSPHORIC ACID

Material	From	Percent nitrogen	Percent phosphoric acid
Tankage	So. Royalton	8.33	9.72
Tankage	"	8.27	8.86
Ground fishscrap	Woodstock	8.23	6.25
Ground bone	Burlington	3.38	21.57

The organic nitrogen in tankage and fish scrap is considered quite readily available. The fishscrap retailed at $31 a ton and, allowing 4 cents a pound for the phosphoric acid, the nitrogen cost 15.8 cents a pound.

MATERIALS FURNISHING AVAILABLE PHOSPHORIC ACID

Material	From	Phosphoric acid				
		Soluble	Reverted	Insoluble	Total	Available
Acid phosphate	Burlington	11.39	2.87	1.95	16.21	14.26
Acid phosphate	Newport	8.54	4.41	1.80	14.75	12 95
Acid phosphate	Hartford	8.24	5 42	1.65	15.31	13.66
Acid phosphate	West Enosburg	8.79	4.70	1.82	15.31	13.49
Acid phosphate	Northfield	9.05	3.94	1.30	14.29	12.99
Acid phosphate	North Bennington	9.03	4.01	1.25	14.29	13.04
Acid phosphate	South Royalton	10.64	4.27	6.40	21.31	14.91
Acid phosphate	East Montpelier	8.99	5.19	1.77	15.95	14.18
Average		9.33	4.35	2.24	15 93	13.69

The available phosphoric acid varies from 12.95 to 14.91 percent. The South Royalton sample was probably made from high grade rock.

MATERIALS FURNISHING POTASH

Material	From	Percent potash
Muriate of potash	Burlington	50.60
Muriate of potash	E. Montpelier	53.52
Muriate of potash	Woodstock	53.08
Muriate of potash	So. Royalton	51.72
Sulphate of potash	Burlington	48.56
Sulphate of potash	E. Montpelier	50.20
Sulphate of potash	Woodstock	51.16

Muriate of potash is guaranteed to contain 80 to 85 percent muriate, equivalent to about 50 percent potassium oxide. The sulphate should likewise contain a similar equivalent. The former varied in price from $41.00 to $46.50 and the latter from $46.00 to $49.25 a ton, making the cost of potash 3.9 to 4.5 cents a pound for muriate, and of 4.6 to 4.9 cents a pound for sulphate.

WOOD ASHES

From	Soluble potash %	Insoluble potash %	Total potash %	Total phosphoric acid %	Calcium oxide %	Insoluble matter %
E. O. Lee, Vernon	4.90	0.37	5.27	1.51	38.76	6.90
J. A. Valentine, Ludlow	6.52	1.14	7.66	1.44	40.14	12.51
V. I. Spear, Randolph	4.48	0.67	5.15	1.60	31.93	11.25
C. G. Miller, Westminster West	3.29	2.13	5.42	1.15	38.36	26.19
W. V. Farr, Westminster Station	4.48	0.50	4.98	3.75	40.96	8.50
A. A. Dunklee, South Vernon	3.94	1.26	5.20	1.59	33.12	14.12
A. A. Dunklee, South Vernon	0.44	0.50	0.94	0.38	35.92	3.55

These samples show the usual variations in potash content. The percentage of soluble potash runs from 3.29 to 6.52. The averages of all ingredients in the first six samples of unleached ashes are 4.60, 1.01, 5.61, 1.84, 37.21 and 13.24 respectively in the order given above.

The insoluble potash, it should be remembered, is of little or no use as plant food, and in one case at least it forms nearly 40 percent of the total potash present. The last sample recorded evidently represents leached ashes, and as a source of potash would be of small value.

It may be said of wood ashes in general that they are often considered as a source of potash only, but that their beneficial effect is many times due to the large percentage of lime they contain. At present prices they are not cheap sources of either potash or lime.

FERTILIZERS AND HOME MIXTURES

From	Nitrogen %	Soluble phosphoric acid %	Reverted phosphoric acid %	Insoluble phosphoric acid %	Total phosphoric acid %	Available phosphoric acid %	Potash %
R. H. Gale, Stowe	2.87	3.22	2.56	0.73	6.51	5.78	4.50
R. H. Gale, Stowe	2.16	----	----	4.85	9.31	4.46	5.88
H. M. Fitch, Wilmington	3.58	4.33	1.36	1.20	6.89	5.69	8.32

For remarks concerning home mixtures and home mixing in general the reader is referred to bulletins 47 and 65 which will be sent on application.

MUCK, ETC.

Material	From	In original substance						In dry matter		
		Water	Ash	Organic and volatile	Nitrogen	Phosphoric acid	Potash	Ash	Organic and volatile	Nitrogen
Muck	O. J. Thomas, Isle LaMotte	71.85	11.44	16.71	0.56	----	----	40.63	59.37	2.00
Muck	H. E. Howard, Elmore	6.03	70.88	23.09	1.05	----	----	----	------	----
Marl	H. E. Howard, Elmore	0.65	89.24	------	----	trace	0.36	----	------	----
Soil	C. E. Butterfield, Bellows Falls	2.10	85.70	12.70	0.50	0.15	trace	----	------	----

The sample of marl contained lime 48.29 percent, carbonic acid 30.50 percent, and insoluble matter 10.70 percent.

The two samples of muck vary greatly in quality, the first being of good grade. Nearly 75 percent of the dry matter in the second sample is sand or soil. The nitrogen in this class of materials is not readily available for plant use.

The sample of soil was from the bottom of a dried up pond, being essentially a low grade muck.

FODDERS AND FEEDS

Material	From	Water	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract
		%	%	%	%	%	%
Dried pumpkin	A. A. Olmstead, S. Newbury	7.45	6.03	9.00	10.19	65.90	1.43
"	" " " "	8.45	7.51	10.31	10.47	61.77	1.49
Hay (1)	W. H. Fuller, Brownington Centre	9.20	4.05	9.19	28.38	46.98	2.20
" (2)	" " " "	8.30	5.64	10.06	21.45	52.05	2.50
" (3)	" " " "	7.58	5.62	10.94	27.33	46.03	2.50
Malted barley meal	Malted Cereal Co., Burl'gton	8.18	3.46	13.56	6.32	65.25	3.23
Malted corn meal	Malted Cereal Co., Burlington	15.05	1.95	11.19	3.71	64.89	3.21
Barley bran	Malted Cereal Co., Burlington	6.90	6.46	5.00	25.98	54.49	1.17
Corn bran	Malted Cereal Co., Burlington	15.70	2.47	12.25	4.12	61.36	4.10
Oatena	Burlington Flouring Co., Winooski	8.10	5.45	5.69	19.93	58.95	1.88
Glucose bran	W. E. Dennis, Boston	6.90	1.14	9.44	14.18	66.74	1.60
Potato feed	W. E. Dennis, Boston	9.50	1.61	3.94	10.68	73.94	0.33
Germ oil meal	H. A. Slayton & Co., Morrisville	7.40	2.18	20.81	9.84	49.80	9.97
Germ oil meal	L. J. Sanderson, Highgate Ctr.	6.25	(*)	25.88	(*)		8.33

* Not determined.

The first pumpkin sample was dried by Mr. Olmstead in a steam evaporator. The other was dried in the station laboratory and contained, when received by us, 88.96 percent moisture. The variations in protein and ash content are quite marked.

The analyses of hay were of samples that had undergone more or less of a spontaneous combustion. No. 1 was from the outside of the mow and appeared normal. No. 2 was partially charred and of a dark brown color. No. 3 was almost black and crumbled in the hand to a fine powder. The palatability more than the composition seems to have suffered alteration.

OLEOMARGARINE

No. 1 from H. Hathorne, Burlington.

No. 2 from F. D. Dutcher, Stamford.

The samples contained 0.30 percent and 0.35 percent, respectively, of volatile acids.

Butter contains upwards of 5 percent volatile acids.

DAIRY FEEDING

J. L. HILLS

The general line of investigation carried out during the past year in this department of the station work has not varied materially from that hitherto followed. Extensive feeding trials, the maintenance of a herd record and observations upon the effect of sundry rations on the quality of butter have been the main subjects of inquiry. Several minor pieces of work have been entered upon but have not as yet been brought to a successful termination.

The experiments completed and written up since the twelfth report was issued are discussed under the following headings:

Feeding trials with cows.
- I. Introduction.
- II. Statement of methods and details of conduct of the feeding experiments.
- III. How much grain can be fed with profit to dairy cows?
- IV. The addition to the ration of excessive amounts of single nutrients.
- V. The feeding value of buckwheat middlings.
- VI. The feeding values of medium and of wide rations.
- VII. The feeding values of rations of approximately equal balance.
- VIII. The grooming of cows.
- IX. Watering cows at will and at intervals.
- X. Warming water for cows.

The effect of feed on the quality of butter.

Records of the station herd for 1898–99 and for 1899–1900.

Appendix containing condensed data pertaining to the article on "feeding trials with cows."

FEEDING TRIALS WITH COWS

This article is summarized at its close, some 45 pages further on in this volume. The results of the trials are concisely stated therein and cross references are given.

I. INTRODUCTION

The general line of feeding tests begun in the winter of 1896–1897 has been followed in the work of the past season. Many of the tests are repetitions of those made the previous year, it being our settled policy to make at least two years' feeding trials of all important matters. Considerable stress has been laid upon the comparison of the relative food values of sundry rations but not to the exclusion of the consideration of important fundamentals in dairy stock-feeding.

The equipment of the station is in many ways well adapted to this line of experimentation. The large size of its herd in particular permits wide range in choice of animals, much repetition of work and the conduct of a relatively large number of trials at one time.

The feeding experiments of the past winter were designed to increase our stock of information on several points. Some of the tests were made in continuation of similar trials in previous years, while the others pertained to matters not hitherto taken up at this station. The questions which the trials were designed to aid in answering were as follows:

(*a*) What is the effect on the quantity and quality of milk and on the economy of production, of low, medium and heavy grain feeding? What is the limit of profit in the addition of grain to a ration?

(*b*) What is the effect on the quantity and quality of milk of the addition to a ration, already apparently fairly well adapted to milk making, of a considerable proportion of a single nutrient (protein, carbohydrates or fat)?

(*c*) What is the feeding value of buckwheat middlings compared with a mixture of corn meal, wheat bran, cottonseed and linseed meals, considerably less rich in protein and fat than is the buckwheat byproduct?

(*d*) What is the feeding value of buckwheat middlings, compared with half corn and half bran, a combination which is far less rich in protein and fat than are the middlings?

(*e*) What variations in production are to be expected from different rations each containing essentially the same amount of digestible dry matter, but different amounts of various nutrients, or, in other words, "medium" and "wide" rations?

(*f*) What variations in production are to be expected from different rations made up to some extent of different materials, each containing essentially the same amounts of the various nutrients?

(*g*) What effect upon the milk flow has the grooming of cows?

(*h*) What is the effect upon the quantity and quality of milk if cows are allowed to drink at will instead of twice daily?

(*i*) Has warming water for cows an appreciable effect upon the quantity and quality of the milk yield?

These feeding trials were known respectively as tests of (*a*) low, medium and heavy grain feeding, (*b*) adding single nutrients, (*c*) buckwheat middlings and mixed feed No. 1, (*d*) buckwheat middlings and corn and bran, (*e*) medium and wide rations, (*f*) equal balance, (*g*) grooming, (*h*) watering and (*i*) warm and cold watering; and are so referred to in this article and in the appendix of tables. Tests *c* to *h* inclusive were made in continuation of similar trials carried out last year and discussed in the last report.[1]

II. STATEMENT OF METHODS AND DETAILS OF CONDUCT OF THE FEEDING EXPERIMENTS

The records of 53 cows were kept in the six and one-half months duration of the feeding trials. The records of five of the original 53 cows for one reason and another are unsafe to use. But little sickness troubled the conduct of the trials. The results of certain periods with a few cows were rendered useless because of temporary illness or because the animal went off feed. In some cases the experimental ration was not to the animals' liking. Palm oil was not relished, buckwheat middlings were unpopular and, at times, certain cows rebelled against an unmixed Quaker dairy feed ration. A few mistakes happened in feeding. It is not strange that some errors of omission and commission occurred or that some sickness intervened to affect results in individual cases, in view of the fact that over 50 cows were fed nearly 200 days under conditions which involved many and, often, radical changes in feed or condition.

The supply of silage ran out a week before the last period closed. The impending shortage necessitated lessening the amounts of silage fed to several cows during the last two periods. More hay was fed in some cases, and the total and digestible dry matters eaten were somewhat, and nutritive ratios decidedly, affected. A most thorough and careful survey of the detailed results during these two periods and of the general outcome has satisfied the writer that the latter has not been materially altered as a result of this enforced change in feeding. Despite these more or less inevitable disturbing factors the outcome of the trials on the whole is quite satisfactory.

The 48 cows whose records are available were distributed among the tests as follows:

(*a*)	Low, medium and heavy grain feeding	11
(*b*)	Addition of single nutrients	10
(*c*)	Buckwheat middlings and cottonseed-linseed mixture (No. 1).	2
(*d*)	Buckwheat middlings and half corn and half bran	2
(*e*)	Medium and wide rations	5
(*f*)	Equal balance	5
(*g*)	Grooming	3
(*h*)	Watering at will and at intervals	4
(*i*)	Cold and warm water	6
		48

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[1] Vt. Sta. Rpt. 12, pp. 253-296 (1899).

All the cows used were not equally well suited to our purposes as regards time of lactation. A long and careful study of previous records—extending over nearly six years with some animals—of ages, times of calving, flow and quality of milk, times of service, etc., prefaced choice for the various experiments. The two feeding tests first named in the schedule on the last page on the whole were given preference in selection.

DETAILS OF FEEDING

The feeding periods were four weeks long. The first 10 days were always considered preliminary and non-experimental and the last 18 were chosen as the experimental portion. The experimental portions only of the periods are considered in the discussion, and are hereinafter referred to as "the period." Results obtained and conclusions drawn are based upon them alone. The preliminary portions were considered as preparatory only, being necessary to get the animal fairly upon and accustomed to its new diet. Notwithstanding this fact, full feeding and milk records were kept, samples of fodders and feeds and milk taken, and analyses made in the same manner and with the same care during the preliminary as during the experimental portions of the periods. All the calculations have been made for the preliminary as well as for the experimental portions.

The cows were fed twice daily, watered twice, except in the trials of methods of watering, and turned out into the yard twice. The yard exercise varied in duration from 20 to 45 minutes according to weather. Hay was first fed morning and night; after this was eaten, as much silage was given as the cow would consume; and then the grain was fed. The amount of hay offered each cow was in the main uniform throughout the tests, but varied between cows according to their digestive capabilities. All fodders and feeds were weighed as fed. The uneaten feed was weighed back daily and its nature noted.

FEEDING PLAN OF ALL TESTS

The formulas, analyses, digestible constituents, etc. of the mixed feeds numbered 1 to 4, and the grains from which they were formed, as well as of the roughages used are shown on page 400. It may be said in brief that No. 1 contained bran, cornmeal, cottonseed and linseed meals, that No. 2 was made up of bran and Buffalo gluten feed, that No. 3 consisted of bran and buckwheat middlings, and that No. 4 contained corn and bran.

All the cows received hay in amounts ranging from 10 to 16 pounds daily, and silage, prior to the shortage, in amounts ranging from 20 to 36 pounds daily.

The changes in daily grain feed were as follows:

(*a*) *Low, medium and high grain feeding.*—Continuous feeding on either mixed feeds No. 1, 2 or 3, amounts varying from 4 to 12 pounds daily, (in one case 16 pounds).

(*b*) *Addition of single nutrients.*—Continuous feeding on No. 1, to which protein (Atlantic gluten flour) was added for one period, carbohydrates (sugar) for another, and fat (palm oil) for another with each cow; these additions alternating with periods in which hay, silage and No. 1 were fed.

(*c*) *Buckwheat middlings and No. 1.*—Rations alternated, 8 pounds each.

(*d*) *Buckwheat middlings and No. 4.*—Rations alternated, 8 pounds each.

(*e*) *Medium and wide rations.*—Quaker dairy feed and No. 1 alternated, 8 pounds each.

(*f*) *Equal balance.*—Quaker dairy feed and No. 4 alternated, 8 pounds each.

(*g*) *Grooming*, (*h*) *watering*, (*i*) *warm and cold watering*—No. 1 throughout, 8 pounds.

In a few cases, the cows being heifers, but 6 pounds of grain were fed.

Comparisons of the amounts of nutrients eaten by the various cows with the Wolff and the Wolff-Lehmann standards show that while there were wide variations in eating as between the different cows and rations there was generally eaten enough and to spare of each of the ingredients except protein. In several cases with the poorer rations, too little protein was eaten. In most cases, however, the amount of this latter nutrient eaten approximated that called for by the Wolff standard except when oat feed, or equal parts corn and bran was eaten. More specific statements touching the comparison with standards are made in the discussion of each test.

WEIGHTS OF COWS

All the cows under test were weighed during the first four days of the opening period, on the last four days of all periods, as well as occasionally during the period as a check. Average weights are shown in table I of the appendix. Nearly two-thirds of the number gained weight during the winter, rather more than a third about held their own—with more or less fluctuation—and one cow—Jersey Lily—lost weight. Variations in live weight are very uncertain factors, and a survey of the data is not very enlightening. There appear, however, to be some general tendencies. A lessened live weight followed a shortened grain ration and an increased weight, a larger ration, more often than when the reverse result or no difference was observed. The addition of gluten and of sugar to the ration was followed usually by increase in weight and never by decrease; palm oil had less effect. The buckwheat middlings, Quaker dairy feed, and mixed feeds 1 and 4 seemed to show no advantages one as compared with another in this respect; nor did the grooming or method of watering affect live weight. When getting cold water the cows weighed rather more than they did when drinking the warmed water.

BARN TEMPERATURES

The cows were stabled in two portions of the barn structure, the main floor and the east wing which leads from the main portion. The temperatures of the two stables were taken daily at 5 A. M., 12 M., and 6 P. M. The exposed location of the station barn causes decided fluctuations in the temperature of the cow stables during the winter, notwithstanding the comparatively large number of animals housed therein.

The average barn temperatures, morning, noon and night, during each period, the ranges of variation and the per cent of the entire number of observations within 3° F. of the mean of each period are tabulated in the appendix. Average variations of 4° or more from means for considerable periods occurred on about 15 days. For several years a careful study was made at this station in connection with its feeding tests, of the fluctuations in yields and of qualities of the milk occurring coincident with, immediately preceding, and immediately succeeding wide thermometric changes. No definite relation has been traced between variations in barn temperatures and in the quality of the milk. Some samples have shown more or less quality fluctuations inverse to temperature changes, others in the same direction, while in many cases no change occurred. It has been held safe to assert that these few changes, mostly slight in amount, had practically no influence in modifying period averages, each of which was based on analyses of several composite samples of milk.

Careful comparisons of variations in milk yield with temperature changes which extended over three or more days were made and four cases of possible relationship were noted, as follows:

February 1–3, 6° F. below mean, 4 percent decrease in milk flow.
February 22–25, 4° F. above mean, 1½ percent increase in milk flow.
March 11–13, 5° F. below mean, 3 percent decrease in milk flow.
May 4–6, 7° F. below mean, 1½ percent increase in milk flow.

In three or four cases a sharp fall in temperature was followed by a lessened yield for one day, normality or nearly such being regained the second day even though cold weather continued.

These cases, which were much the largest fluctuations occurring coincidently with temperature changes extending over more than a day or two, are so small as to be quite without effect upon the average of results obtained in periods 18 days in length. A more uniform barn temperature than is attainable under our conditions would have been an advantage; but it is judged from these comparisons that temperature variations had little if any effect on the final results. It should be noted, moreover, that, since all the cows were housed together, these effects, if any, might be expected to be uniformly exerted on all; and that in every trial cows were being alternated on feeds, there being some fed on each ration at all times. It should be remembered also, in this connection, that all the cows were turned out daily for from twenty to forty minutes.

PERIODS AND COWS

The following tables show the period dates and the cows in use, with the nature of the grain feed eaten during each period. The names which are italicised are those of registered Ayrshires, the small capitals indicate registered Jerseys, while the names given in ordinary type are those of high grade Jerseys.

COWS USED AND NATURE OF GRAIN RATIONS, ETC., FED OR TREATMENT DURING EACH PERIOD

Name	Approximate age Nov. 1	Calved 1899	Served 1900	Period numbers							
				Feed	I	II	III	IV	V	VI	VII
Low, medium and high grain feeding											
BEAUTINA	8	Sept.	Mch. 25	No. 1	low	med	high	med	low	med	high
Dahlia	8	Sept.	Aug. 12	“	“	“	“	“	high	“	med
Acme 5th	10	Dec. 4	Mch. 10	“	------	“	“	“	low	“	high
Nancy B	12	Nov. 18	Feb. 16	“	------	“	low	“	“	“	“
Rosemary	5	Sept.	Mch. 15	No. 2	low	“	high	“	“	“	“
Eulalie	10	Nov. 13	Aug. 4	“	“	“	“	†high	high	“	low
Pomona	8	Dec. 27	Apr. 4	“	------	------	“	med	low	“	high
Inez	7	Nov. 14	Mch. 23	“	med	med	low	“	high	“	------
Star Bright	3	Oct. 31	Mch. 16	No. 3	low	“	high	“	low	“	------
Rachel	8	Nov. 22	Farrow	“	------	“	“	“	“	“	------
Pussy Willow	8	Jan. 6 '00	Apr. 4	“	------	------	med	“	“	“	------
Addition of single nutrients											
Ceres	9	July 30	Feb. 6	------	1	oil	1	gluten	1	sugar	1
Cowslip	4	Oct. 15	Dec. 18'99	------	1	gluten	1	sugar	1	oil	1
Haidee	4	Nov. 21	Apr. 9	------	------	“	1	“	1	“	1
Ladysmith	6	Sept.	Dec. 6	------	1	sugar	1	oil	1	gluten	1
Naomi	4	Dec. 20	Mch. 20	------	------	------	1	“	1	“	1
Pauline	4	Dec. 10	June 20	------	------	sugar	1	“	1	“	1
Pretoria	3	Sept.	Aug. 19	------	1	oil	1	gluten	1	sugar	1
Priscilla	4	Nov. 13	Apr. 28	------	1	gluten	1	sugar	1	oil	1
Ruth	4	Sept. 2	Apr. 1	------	1	oil	1	gluten	1	sugar	1
JERSEY LILY	8	Dec. 24	Mch. 31	------	------	------	gluten	1	gluten	1	gluten
Buckwheat middlings and mixed feeds, 1 and 4.											
Idarella	9	Nov. 2	June 10	------	B M	1	B M	1	B M	1	------
Suenette	4	Aug. 23	Oct. 16'99	------	1	B M	1	B M	1	B M	1
Buttercup	3	Aug. 29	June 8	------	B M	4	B M	4	B M	4	------
Serena	3	Sept. 12	Apr. 3	------	4	B M	4	B M	4	B M	4
Medium and wide rations											
Dime	3	Jan 19'00	Aug. 22	------	------	------	------	1	Q D F	1	Q D F
Eva	7	July 1	Jan. 24	------	------	1	Q D F	1	“	1	“
Jip	6	Sept. 18*	Farrow	------	1	Q D F	1	Q D F	1	Q D F	------
Maizie	13	Nov. 23 '98	Farrow	------	------	1	Q D F	1	Q D F	1	Q D F
MAX BELLE	7	June 20	Oct. 25 '99	------	1	Q D F	1	Q D F	1	Q D F	1
Equal balance											
Dandelion	10	Feb. 28	Farrow	------	------	4	Q D F	4	Q D F	------	------
Fairie	10	Mch. 9	Aug. 11'99	------	------	4	“	4	“	------	------
Goldenrod	8	Apr. 23	July 8 '99	------	4	Q D F	4	Q D F	------	------	------
Rowena	8	May 22	Farrow	------	4	“	4	“	4	Q D F	4
Viola	3	Feb. 20'00	Mch. 31	------	------	------	------	------	Q D F	4	Q D F
Grooming											
Bettie	11	Nov. 19*	Farrow	------	------	groom	no gr.	groom	no gr.	groom	------
Polela	5	Jan. 20 '00	Mch. 20	------	------	------	------	no gr.	groom	no gr.	groom
Salida	6	Feb. 5 '00	June 18	------	------	------	------	“	“	“	“
Water at intervals and at will											
Flora	10	Feb. 6 '00	July 11	------	------	------	------	int.	will	int.	will
LADY PERUSIA	6	Feb. 6 '00	May 28	------	------	------	------	“	“	“	“
Max Ella	8	Jan. 13 '00	Mch. 15	------	------	------	------	will	int.	will	int.
MINTA BELLA	8	Feb. 14 '00	Apr. 10	------	------	------	------	------	“	“	“
Warm and cold water											
Atalanta	10	Nov. 16'98	Oct. 10 '99	------	warm	cold	warm	cold	warm	cold	------
Clare	12	Jan. 22	July 4 '99	------	“	“	“	“	------	------	------
Edna	6	July 1	Jan. 15	------	“	“	“	“	warm	cold	warm
Orpha	7	July 30	Dec. 27	------	------	warm	cold	warm	cold	warm	cold
Red Top	10	May 8	July 21'99	------	cold	“	“	------	------	------	------
Sylvia	7	Aug. 10	Sept 28'99	------	“	“	“	warm	cold	warm	------

*Aborted. †Very high.

DATES OF FEEDING PERIODS

I	Preliminary	Nov. 9–19.
	Experimental	Nov. 19–Dec. 7.
II	Preliminary	Dec. 7–17.
	Experimental	Dec. 17–Jan. 4.
III	Preliminary	Jan. 4–14.
	Experimental	Jan. 14–Feb. 1.
IV	Preliminary	Feb. 1–11.
	Experimental	Feb. 11–Mch. 1.
V	Preliminary	Mch. 1–11.
	Experimental	Mch. 11–29.
VI	Preliminary	Mch. 29–Apl. 8.
	Experimental	Apl. 8–26.
VII	Preliminary	Apl. 26–May 6.
	Experimental	May 6–24.

MILKING AND MILK SAMPLES

Every milking was weighed from the outset to the end of the feeding trials. Composite samples of six and eight milkings were taken continuously during both the preliminary and the experimental portions of the periods. These were analyzed by the Babcock centrifugal method for fat, while the total solids were furnished by the Quevenne lactometer, the Hehner and Richmond formula ($T=1.2\ F+(\frac{L}{4})+0.14$), the fat percentage and the milk slide-rule.

FODDERS AND FEEDS

The fodders and feeds were sampled once a fortnight, 23 samples of roughages and of concentrates (grain feeds) being taken. All samples were individually analyzed for their dry matter content, and were then combined to make 59 composite samples for complete analysis. Tables of analyses, of digestion coefficients and of digestible nutrients appear in the appendix; the averages of these are shown on the next page.[1]

The hay fed was in general a good grade of early cut hay of mixed grasses, mostly timothy and herdsgrass with considerable clover. Some oat hay was fed for a few days in February owing to a misunderstanding. So many cows were fed so long that it was impossible to feed an even grade of hay throughout, but, with the above exception, there was no serious variation in the quality of the hay fed throughout the trials. The silage was from matured Sanford corn well eared. It kept well and was but slightly acid. A few samples of silage were very low in dry matter. These were analyzed separately. They are thought to represent but a small portion of the entire lot. The bran was roller process, Pillsbury make. The buckwheat middlings from the Chittenden mills, Jericho, were of high grade—with the exception of a small lot bought towards the end of the trials to piece out. The other grain feeds used are indicated by their trade marks. The mixed feeds were made from time to time as needed in accordance with the formulas shown in the foot-note on the next page.

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[1] For more complete statement of methods of sampling and for individual analyses see able III in appendix and footnote to same.

AVERAGE ANALYSES OF FODDERS AND FEEDS

Fodders and feeds	Original substance		Composition of dry matter							
	Water	Dry matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Nitrogen	Phosphoric acid	Potash
Hay	13.35	86.65	7.00	10.56	30.34	48.81	3.29	1.69	0.50	2.08
Silage	73.00	27.00	6.57	9.27	23.00	57.84	3.32	1.48	0.62	1.84
"	78.27	21.73	8.22	11.04	24.25	53.13	3.36	1.77	0.65	1.92
*Mixed feed No. 1	13.32	86.68	6.04	26.37	11.19	50.22	6.18	4.21	2.81	1.74
" No. 2	10.82	89.18	3.48	24.47	9.98	57.47	4.60	3.91	1.70	1.01
" No. 3	11.04	88.96	5.65	28.86	8.75	49.20	7.54	4.62	2.96	1.60
" No. 4	12.12	87.88	4.19	14.48	7.93	67.99	5.41	2.32	1.91	1.25
Wheat bran	10.81	89.19	6.71	17.13	12.98	57.58	5.60	2.74	3.32	2.05
Corn meal	13.34	86.66	1.51	11.26	2.75	79.30	5.18	1.80	0.65	0.48
Cottonseed meal	9.19	90.81	6.98	51.27	5.56	26.94	9.25	8.20	3 74	2.29
Cleveland flax meal	11.56	88.44	5.58	39.89	11.23	38.63	4.67	6.38	1.71	1.50
Buffalo gluten feed	8.33	91.67	1.97	28.83	8.23	56.98	3.99	4.61	0.92	0.47
Buckwheat middlings	10.17	89.83	4.65	34.42	5.72	46.40	8.81	5.50	2.76	1.34
Quaker dairy feed	7.95	92.05	4.84	13.56	20.90	57.38	3.32	2.17	0.65	0.73
Atlantic gluten flour	7.84	92.16	1.04	88.19	0.18	8.59	2.00	14.11	0.52	0.12
Sugar	5.47	94.53	1.74	-- --	-- --	88.00†	------	-- --	- --	- --
Palm oil	2.06	97.93	- --	-- --	-- --	-- --	100.11	-- --	- --	- --

* The mixed feeds were made up as follows:

No. 1, cottonseed meal 3 parts, flax (linseed) meal 3 parts, corn meal 2 parts, wheat bran 8 parts.

No. 2, Buffalo gluten feed 2 parts, wheat bran 1 part.

No. 3, buckwheat middlings 2 parts, wheat bran 1 part.

No 4, equal parts cornmeal and wheat bran.

† Sugar by direct polarization; 90 per cent nitrogen-free extract assumed to be present in original substance.

AVERAGE DIGESTIBLE INGREDIENTS IN FODDERS AND FEEDS

Fodders and feeds	Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	Nutritive ratio
Hay	52.0	5.21	15.3	27.1	1.6	1: 8.8
Silage (mature corn)	19.7	1.58	4.7	12.1	0.8	1:11.8
" (less mature corn)	15.8	1.53	4.0	8.9	0.6	1: 9.3
Mixed feed No. 1	61.6	19.0	4.1	33.1	4.4	1: 2.5
" No. 2	69.6	18.3	5.2	42.0	3.3	1: 3.0
" No. 3	63.2	20.5	2.4	33.3	5.5	1: 2.3
" No. 4	66 8	9.4	1.7	50.4	3.7	1: 6.4
Corn meal	77.1	6.6	- --	65.3	4.1	1:11.3
Wheat bran	55.3	11.9	3.4	35.3	3.4	1: 3.9
Cottonseed meal	67.2	40.9	2.8	14.9	7.8	1: 0.9
Cleveland flax meal	69.9	30.0	8.0	29.4	4.0	1: 1.5
Buffalo gluten feed	78.9	22.7	5.9	46.5	3.1	1: 2.6
Buckwheat middlings *	67.3	24.7	1.7	33.8	6.8	1: 2.1
Quaker dairy feed	57.1	10.1	8.3	35.4	2.7	1: 4.9
Atlantic gluten flour	83 0	68.3	- --	7.2	1.7	1: 0.2
Sugar (assumed)	94.0	-- --	- --	90.0	- --	----
Palm oil (assumed)	78.4	-- --	- --	- --	78.4	----

* Wheat middlings digestion coefficients used for buckwheat middlings.

RECORDS OF THE FEEDING TESTS

The experimental feeding and care of 53 cows for from three to six and a half months involved a vast amount of labor. It necessitated over 60,000 barn weights and records, the analysis of 237 samples of fodders and feeds for dry matter, of 59 similar materials for the various crude nutrients (complete analysis) and of about 2400 composite samples of milk for fat and specific gravity. And, finally, many hundreds of hours of work were spent in the collation and calculation of the multitudinous records of the tests in preparation for publication. All the mathematical work in connection with this, as with all other similar station work, was done in duplicate, usually by different persons, and was accomplished so far as possible with the aid of calculating instruments and tables. It is thought to be absolutely accurate. The detailed data if printed would add more than 200 pages to this report. Even when condensed into the briefest possible compass it occupies much space. Our usual custom of placing in an appendix the condensed data which forms the basis for our conclusions has been followed in the present case. It is there of ready reference to those interested, but does not stand in the way of that larger class of readers who care only for the text and for the smaller tables showing final results. Only those tables absolutely necessary to the explanation of the text are included in the body of the articles. The main tables appear in the appendix to this volume under the following headings:

APPENDIX CONTAINING CONDENSED DATA PERTAINING TO ARTICLES ON FEEDING TRIALS WITH COWS

I. Weights of cows.
II. Average barn temperatures, with ranges and percentages of uniformity.
III. Analyses and digestible ingredients in fodders and feeds; (*a*) analyses on dry basis, and pounds of digestible nutrients in 100 pounds of original substance; (*b*) digestion co-efficients.
IV. Feeding records of the individual cows in feeding tests.
V. Production records; showing production and same per unit for each individual cow in feeding tests.
VI. Difference tables. (*a*) Total of differences; (*b*) Percentage differences.
VII. Results of experimental feeding on different rations.

This appendix is omitted in the edition distributed to the state mailing list, since it is composed simply of a mass of figures, of interest only to the student of animal husbandry and as a matter of record as the basis for the conclusions drawn from these trials. Copies may be obtained on application by such parties as may desire to view it. It is printed in the edition sent to the out-of-the-state and the station lists.

III. HOW MUCH GRAIN MAY BE FED WITH PROFIT TO DAIRY COWS?

The feed bill of the state of Vermont approximates $3,500,000 annually or about ten dollars for each inhabitant. No statistics exist showing the proportion used by the sundry classes of farm live stock, but unquestionably much the larger part is fed to cows. Is this an excessive bill or is there value received for the money invested?

The greater part of this vast sum is paid for western corn meal and oats, good dairy feeds, which, however, should be grown rather than bought by Vermont farmers. More protein and less carbohydrates, more of the offals of the oil, glucose and milling industries and less corn and oats should be bought. This would benefit alike the butter product, the manure pile and the pocket book.

There is a wide divergence in the practice of New England dairymen as to choice of feeds in making up their rations, a divergence brought about by a multitude of causes. To a less extent there is difference of opinion and practice as to the amount of grain fed. The number of possible combinations of the sundry feeds is legion, while a cow can but seldom be persuaded to eat more than 16 or 18 pounds of any of them daily, or to get along on "less than nothing." Yet there is every reason to suppose that, given two grain combinations fairly well adapted to meet the physiological needs of a cow when fed with proper supplies of roughages, the amount of grain fed bears a closer relation to profit than does the nature of the grain ration.

Some successful dairymen advocate liberal feeding with concentrates while others use scant rations. Few feed less than 2 or more than 12 pounds daily, although in isolated cases as much as 16 pounds are fed. The generality of feeders use from 4 to 12 pounds of grain feed daily. This wide divergence in practice among different feeders may be warranted by circumstances. Sundry local conditions, such as the nature and amount of roughage on hand, the distance from sources of supply, the character and the cost of each, the price of butter, cheese or milk, and—most important—the dairy abilities of the cows, all of these as well as other considerations enter into the problem. Thus while it may pay one man to feed heavily another might find such practice unprofitable. High prices for butter encourage liberal feeding, high prices of feeds discourage it. The owner of the hearty, gross feeder can often feed relatively less grain and more roughage than can the dairyman whose cows have a smaller digestive capacity. He who has grown largely of clover, peas and oats, who has early cut hay and rowen in plenty as well as good well eared silage, is less dependent upon the miller's stock than his neighbor who has not farmed as intensively. Yet when all is said much variation is found in practice where conditions are not greatly dissimilar. Hence it may be queried very properly whether both he who feeds four and he who feeds twelve pounds of grain are doing wisely. Is the one losing money from underfeeding or the other throwing away money from overfeeding? There is clearly need of work along these lines.

This station in common with many others has studied for years the relative economies of sundry grain rations differing one with another as to their ingredients. But little has been done however in this country towards measuring the relation of the amount of a grain ration to profit. The Wisconsin station[1] has recently made two reports of investigation of this matter which form the most important contributions to the subject which have met the writer's eye. The beginning of a series of trials, which, it is expected, will extend over several years, was made in the winter of 1899-1900 at this station with a view of attempting to measure the relation of the amount of grain fed to profit. The result of the first winter's trial is reported herewith. The second winter's test is well under way at the present writing and is on a yet more extended scale. It is hoped that the continued investigation may in time enlarge our information on this important matter.

GENERAL PLAN

It was planned to use 12 cows, all—or nearly all—comparatively fresh in milk; to feed three different grain rations to three lots of four cows each; and to maintain the even character of the feeding of each cow throughout the six and a half months in every respect except as to the amount of grain fed. It was intended to vary the amounts of grain fed from 4 to 8 and from 8 to 12 pounds in successive periods, thence back again through 8 to 4 pounds and then up again to 12 pounds. This sequence sometimes started with 4 pounds and worked upwards, sometimes began with 12 pounds and worked downwards. This exact plan was not always carried out. There were one or two errors in feeding; some cows came in later than was expected; and one cow fell sick. These occurrences simply lessened the number of possible observations and in no other way affected the results.

The comparison of one feed with another was made in the usual fashion. It was assumed that the mean of the results of eating, production, etc., of two separate periods—when similar amounts of grain were fed—would have been the consumption, production, etc., in the intermediate period, had there been no change in the ration. This assumption, it must be confessed, has less validity than usual when stretched to cover so wide a break as between the first and fifth periods which had occasionally to be done; but this seemed—as the experiment was planned—the only feasible means of comparison. It is thought, however, that the essential results are not altered by this procedure.[1] It may be remarked that the experiments for 1900–1901 are so planned as to obviate this difficulty.

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[1] Wis. Sta. Rpts. 16, pp. 52-67 (1899), 17, pp. 37-61 (1900).

FEEDING

The eleven cows which were used were all fresh in milk; three were about six weeks along in lactation, the remainder but a week or two when started on the experimental feeding. Ten of the eleven were mature animals. Their past histories as regards performance at the milk pail, and their adaptation to the trials were carefully scanned together with those of all the other cows which were available before choice was made. It is felt that they were well adapted to the purpose. The grain rations used were, No. 1, (bran 8 parts, corn meal 2 parts, cottonseed meal 3 parts, linseed meal 3 parts); No. 2, (bran 1 part, Buffalo gluten feed 2 parts); and No. 3, (bran 1 part, buckwheat middlings 2 parts). They were eaten readily in the low and medium amounts, but less completely by some cows where the larger amounts were fed. Dahlia, Rosemary and Inez, eating respectively mixed feeds 1, 2 and 3, were quite shy feeders. At no time were the cows off feed even when at the highest notch of feeding.

COMPARISON WITH STANDARDS[2]

Wolff[2].—When the cows were on medium or high grain feed dry matter and digestible dry matter was always eaten in excess of standard requirements. The several digestible nutrients eaten were always equal to and usually greater than the standard calls for. When the cows were fed the low grain ration they ate either a close approximation to or more than standard requirements of total and of digestible dry matter, and generally of digestible carbohydrates, but the protein consumption was always low. In other words, as judged by the Wolff standard, the cows ate plenty of food at all times, often a considerable excess, but when the grain feed ran low, it was not well balanced.

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[1] This method of calculation and comparison may be made more clear by example. Thus the cow Beautina—whose record leads the entire list in table 4 in the appendix—was fed in the successive periods as follows: I, low ration; II, medium ration; III, high ration; IV, medium ration; V, low ration; VI, medium ration; VII, high ration. It is assumed that she would have eaten and produced in period III, had she been continued on the low ration, the mean of what she actually ate and gave in periods I and V when she was fed the low ration; that had she been continued on the medium ration she would have eaten and given in period III the mean of what she actually ate and gave in periods II and IV on the medium ration. We thus have her calculated consumption and production for period III on low and on medium feeding and her actual consumption and production for the same period on high grain feeding. Similarly the consumption and production of V may be calculated from the means of III and VII (high) and of IV and VI (medium.)

See in this connection table 4 (page 406) and the remarks immediately following on page 407; also matter under subhead 7 on page 408.

[2] See footnote 1 on next page.

Wolff-Lehmann.[1]—When the cows were fed on medium or high grain feed total and digestible dry matters were eaten by nine of the cows in excess of standard requirements, as were also the several digestible ingredients. The two heavy and deep milking Ayrshires, however, ate no more than and often less than the standard calls for. When the cows were stinted on grain they seldom ate total dry matter or digestible protein enough, but they generally ate enough or more than enough digestible dry matter and carbohydrates to meet standard notions.

The nutritive ratios of the sundry rations are grouped herewith.

Mixed feeds	Low feeding		Medium feeding		High feeding	
	Range	Average	Range	Average	Range	Average
No. 1	1:6.9—1:7.6	1:7.3	1:5.1—1:6.2	1;5.7	1:4.4—1:5.3	1:4.8
No. 2	1:5.9—1:7.7	1:7.1	1:4.4—1:6.7	1:5.2	1:5.0—1:5.9	1:5.3
No. 3	1:6.7—1:7.7	1:7.3	1:4.4—1:6.1	1:5.7	1:4.2—1:4.3	1:4.3

RESULTS

As has been already remarked—page 401—the data of these feeding trials, although greatly condensed, are, notwithstanding, voluminous. As few figures as possible are given in the text. It is thought, however, that the scheme of tabulation is made clear by the captions of the tables and by the footnote at the bottom of the next page.

The following tables[2] summarized from those at various points in the appendix, show the increase or decrease—expressed as percentages, total equalling 100—in dry matter eaten, in milk, total solids and fat yielded and in products to the 100 pounds of dry matter eaten when:

Table 1. Hay, silage and 8 pounds of grain were fed instead of hay, silage and 4 pounds of grain (*medium and low grain feeding*).

Table 2. Hay, silage and 12 pounds of grain were fed instead of hay, silage and 4 pounds of grain (*high and low grain feeding*).

Table 3. Hay, silage and 12 pounds of grain were fed instead of hay, silage and 8 pounds of grain (*high and medium grain feeding*).

Table 4. Hay, silage and 8 pounds of grain were fed in comparison with the same.

These different rations had the nutritive ratios indicated above.

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[1] The reader's attention is called to the full discussion of the nature and usefulness of standards in bulletin 81 of this station entitled "Principles and Practice of Stock Feeding." This bulletin of 56 pages will be sent without charge, upon application, to any address.

[2] See footnote on next page.

SUMMARY OF DIFFERENCE TABLES,* ETC., (APPENDIX VI (*b*) AND VII)

RATIONS (*a*) When changed from the lower to the higher ration (*b*) When changed from the higher to the lower ration (*c*) When changed from the lower to the higher ration	Periods represented or days of feeding	Dry matter	Dry matter in experimental feed	Quantity of milk	Total solids, per cent	Fat, per cent	Quantity of total solids	Quantity of fat	Product per 100 pounds of dry matter			Ratio of fat to solids-not-fat
									Milk	Total solids	Fat	
TABLE 1. MEDIUM AND LOW GRAIN FEEDING												
(*a*) Low to medium	5	+13	+ 92	+ 4	+2	+6	+ 6	+10	— 8	— 6	— 3	...
(*b*) Medium to low	9	—13	— 50	—10	—1	—2	—10	—10	+ 4	+ 3	— 2	...
(*c*) Low to medium; M.F.No. 1	144	+12	+101	+ 8	0	+2	+ 8	+10	— 4	— 3	— 2	—2
(*c*) " " " No. 2	108	+14	+ 92	+ 9	+1	+2	+11	+12	— 5	— 3	— 2	—1
(*c*) " " " No. 3	126	+13	+ 99	+ 3	+2	+4	+ 5	+ 8	—10	— 8	— 6	—4
(*c*) " " Total of Nos. 1, 2 and 3	378	+13	+ 98	+ 7	+1	+3	+ 8	+10	— 6	— 5	— 4	—3
TABLE 2. HIGH AND LOW GRAIN FEEDING												
(*a*) Low to high	4	+25	+186	+13	+4	+5	+17	+19	— 9	— 9	— 5	...
(*b*) High to low	4	—20	— 66	—20	+2	+6	—19	—15	— 1	— 1	+ 5	...
(*c*) Low to high; M. F. No. 1	72	+24	+202	+24	—1	—3	+23	+19	+ 1	— 1	— 4	+4
(*c*) " " " No. 2	90	+23	+171	+18	0	—2	+19	+18	— 3	— 2	— 4	+3
(*c*) " " Total of Nos. 1 and 2	162	+24	+185	+21	0	—3	+21	+19	— 1	— 2	— 4	+4
TABLE 3. MEDIUM AND HIGH GRAIN FEEDING												
(*a*) Medium to high	10	+ 8	+ 38	+ 8	+1	—1	+ 9	+ 7	0	+ 1	— 1	...
(*b*) High to medium	5	— 8	— 30	—10	+1	+4	— 9	— 6	— 2	— 1	+ 2	...
(*c*) Medium to high; M.F.No. 1	198	+ 9	+ 44	+14	0	—3	+13	+ 9	+ 4	+ 3	0	+4
(*c*) " " " No. 2	180	+ 9	+ 45	+ 8	—1	—3	+ 7	+ 5	— 1	— 2	— 2	+4
(*c*) " " " No. 3	54	+10	+ 39	+ 4	+2	+3	+ 6	+ 7	— 6	— 4	— 2	—2
(*c*) " " Total of Nos. 1, 2 and 3	432	+ 9	+ 44	+10	0	—1	+ 9	+ 7	— 1	— 1	0	+2
TABLE 4. MEDIUM AND MEDIUM GRAIN FEEDING. (A CHECK ON EXPERIMENTAL ERROR AND A MEASURE OF ITS EXTENT)												
(*a*) Medium to medium	8	— 2	— 2	— 4	+1	+2	— 3	— 3	— 3	— 2	— 2	...

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* These tables and several others in the sections of this article numbered IV to X are so very highly condensed that, unless further explained, they are likely to prove unintelligible. In the first place the reader is directed to the two pages of text at the end of the appendix explanatory of the so-called "difference tables." The nature of these tables—which aim to measure the relative feeding values of the sundry rations,—and of the summaries given in the text of this article is shown therein at length.

The tables 1 to 4 given above, as well as the several following printed in the discussion show the *increase or decrease, as the case may be, in the amounts of dry matter eaten, of milk, solids and fat yielded, and of production proportioned to 100 pounds of dry matter when one ration replaced another.* These increases and decreases are expressed as *percentages* of the total, total equalling 100. Thus for example the 11 cows fed low and medium rations for 378 days (last line table 1) ate 8394 pounds of dry matter when getting the lower and 9493 pounds of dry matter when fed the medium ration. They ate 1099 pounds more dry matter (9493—8394) on the latter ration, which is an increase of 13 per cent (1099÷8394)=.13+) over the feeding on the low ration. This figure, +13, an increase of 13 per cent in dry matter, appears in the appropriate column at the bottom of table 1. immediately to the right of the figure 378. It shows that when a change was made from a low to a medium grain ration 13 per cent more dry matter was eaten as a result of that change. In other words +13 is in this case the "percentage of increase," "total (8394) equalling 100." All the other figures, be they + or — increases or decreases, in these and the similar tables further along in this article, were thus derived and have a similar significance.

Table 4 shows the increases or decreases in consumption and production, when no change whatever was made, when the medium 8 pound ration was fed in each case. This comparison is, in a measure, a check upon the work, since it shows what might be termed the experimental error—and its probable extent—incident to the method of feeding and the scheme of calculation used. The comparatively even run of figures and their relatively low value add strength to the conclusions which may be drawn from the other data.

It should be noted that in each table (*a*) indicates the percentage results obtained when the second named ration was substituted for the first—the former being always the richer ration; that (*b*) represents the outcome when the poorer ration was substituted for the better one; and that (*c*) shows the percentage gain or loss resulting from 54 to 432 days' feeding on the richer as compared with the poorer ration. These three comparisons were obtained with the same cows in the same series of tests. They are arrived at, however, in three different ways, yet they all tell much the same story.

CONCLUSIONS

The strict verbalized summary to be made from table 1,—which is typical of those which might be drawn from tables 2, 3 and several others following in this article—may be stated as follows:

1. Thirteen percent more dry matter fed in the medium ration than was eaten in the low ration produced 4 percent more milk, 6 percent more solids and 10 percent more fat and butter, but at the expense of 8, 6 and 3 percents, respectively, more dry matter. (*a*).

2. Thirteen percent less dry matter fed in the low ration than was consumed when the medium ration was given made 10 percent less milk, solids, and fat and butter, but at a saving of from 2 to 4 percent of dry matter. (*b*).

3. Thirteen percent more dry matter fed 378 days in the medium ration than was eaten in the same time on the lower feed made 7, 8 and 10 percents respectively more milk, solids and fat, at the expense of 6, 5 and 4 per cents respectively more dry matter. (*c*).

This statement is exact and categorical. It is the direct interpretation of the tabulated data into text; but it is rather confusing. It has been deemed expedient therefore to make the verbal conclusions less exact but not less correct as generalizations. This course will be taken with all the tabulations of this character in this article.

The outcome as regards production and economy of production in this series of trials may be stated in the following inferences:

1. *Low and medium grain feeding.*—When 4 pounds of grain were added to a ration of hay, silage and 4 pounds grain there was made from 7 to 10 percent more milk, solids and fat, and the quality of the milk was

very slightly improved. The increase in dry matter eaten was 13 percent; hence 100 pounds of dry matter made from 4 to 6 percent less product on the medium than it did upon the poorer ration.

2. *Medium and low grain feeding.*—Dropping 4 pounds of grain from a ration of hay, silage and 8 pounds of grain resulted in 10 percent lessened production and slightly poorer milk. There was 13 percent less total dry matter eaten; hence a unit of dry matter made from 2 to 4 percent more milk, total solids and fat on the poorer than was made on the better ration.

3. *Low and high grain feeding.*—When 8 pounds of grain were added to a ration of hay, silage and 4 pounds of grain there was a fifth more milk, solids and fat made, but it took a fourth more dry matter to make them; and hence the unit of dry matter produced more when the scant ration was fed than when the better one was used.

4. *High and low grain feeding.*—When 8 pounds of grain were dropped from a ration of hay, silage and 12 pounds of grain a fifth less dry matter was fed and from 15 to 20 percent less milk, total solids and fat were made. The quality of the milk was bettered considerably and, as a result, while the producing power of a pound of dry matter was the same in each ration, so far as milk and total solids were concerned, the low ration proved 5 percent better than its competitor in the production of fat.

5. *Medium and high grain feeding.*—When 4 pounds of grain were added to a ration of hay, silage and 8 pounds of grain there were made from 7 to 10 percent more milk, solids and fat. Nine percent more dry matter was eaten. The producing power of a pound of dry matter was practically the same in each ration. No change was observable in the quality of the milk.

6. *High and medium grain feeding.*—When 4 pounds of grain were dropped from a ration of hay, silage and 12 pounds of grain, production was lessened from 6 to 10 percent, 8 percent less dry matter was fed, a slightly better milk seemed to be made, and the producing power of a unit of dry matter remained unaltered.

7. *Medium and medium grain feeding.*—When like rations were fed at diverse times, and when, by calculation, the effects of advancing lactation had been so far as may be neutralized, the results arrived at by comparing calculated and actual yields were found to be closely alike. Two percent less dry matter made 3 and 4 percent less product, while the unit of dry matter made from 2 to 3 percent less as calculated than was actually yielded. The quality of the milk was essentially unaltered. It would appear, therefore, that the extent of the experimental error due to the method of comparison used in the trials is relatively small.

The outcome of these trials summarized from the standpoint of product rather than of feeding may be stated as follows:

1. *Quantity.*—The more grain, the more milk, total solids and fat.

2. *Quality*.—No changes worth chronicling were observed. Such slight variations as occurred were in the general direction of better milk on medium than on either low or high grain feeding.

3. *Economy of production*.—A pound of dry matter went further and made more milk, total solids and fat on low than on either medium or high grain feeding. But slight differences in this respect were observable as between the medium and the high rations.

4. *Live weight*.—Some of the cows responded to the radical changes in the amount of grain fed entirely by way of the milk pail; some lost or gained flesh as feed was added or withdrawn; and some lost flesh on the higher ration, being apparently stimulated to turn both feed and flesh into the milk channels. In the earlier periods and months of lactation increase of feed usually affected the milk flow only, but beginning with the fourth month its effect was shown more, and to a greater extent, in the live weight.

The outcome may be graphically illustrated as follows:

	Low to medium	Medium to low	Low to high	High to low	Medium to high	High to medium	Medium to medium
Quantity	+	−	+	−	+	−	−
Quality	+	−	+	+	O	+	O
Economy of production	−	+	−	O & +	O	O	−

FINANCIAL CONSIDERATIONS

The discussion thus far has been directed to a consideration of the effect of increasing grain rations upon production and upon the economy of production. A more direct study of the financial side of the operation is now in order. *Does it pay to feed cows 8 or 12 pounds of grain daily?*

The following tables show:

1. The weights of the various fodders and feeds eaten.
2. The weights of milk and butter produced.
3. The money value[1] of the food eaten.
4. The cost of food for 100 pounds of milk and for 1 pound of butter
5. Proceeds of butter sales at 20 cents a pound.
6. The fertilizing value[2] of the rations.
7. The total value of all production, butter, skim milk[3] and two-thirds of fertilizing ingredients.
8. Gain, net gain, and daily net gain of one ration over another.

These are shown for the experimental portions of the periods only. Lactation stages are exactly equalled by calculation; hence each ration has the same chance as its rival to prove its worth.

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[1] Hay $10, silage $3, corn meal $18, bran $18, cottonseed meal $26, linseed meal $26.50, Buffalo gluten feed $22.20, buckwheat middlings $21.20; average market prices for grain feeds, and average estimates of many prominent and successful farmers in various portions of the state of the money values of hay and silage at the barn ready for feeding.

[2] Nitrogen 15½ cents, phosphoric acid 4 cents, potash 4¼ cents; 1900 trade values for the same ingredients of essentially similar availability in commercial fertilizers.

[3] Allowing 20 cents a hundred for skim milk, its feeding value in our more recent experiments.

COMPARATIVE VALUES OF VARIOUS RATIONS FROM THE FINANCIAL STANDPOINT

RATIONS	Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Buffalo gluten or buckwheat middlings	Milk	Butter	Money value of food	Cost of food for		Proceeds for butter at 20 cents	Fertilizing value of food eaten
										100 lbs. of milk	1 lb. butter		
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	$	cts.	cts.	$	$
144 DAYS ON LOW RATION VS. 144 DAYS ON MEDIUM RATION (NO. 1, COTTONSEED, LINSEED, CORN AND BRAN)													
Low	1906	5042	72	288	216	.....	3380	171	23.17	68.6	13.6	34.20	15.08
Medium	1881	4994	144	576	432	.....	3653	188	29.05	79.5	15.5	37.60	19.37
Differences in favor of medium ration							+273	+ 17	+ 5.88	+10.9	+ 1.9	+ 3.40	+ 4.29
Percentage differences							+ 8	+ 10	+ 25	+ 16	+ 14	+ 10	+ 28

Total value of butter, skimmilk and two-thirds of fertilizing ingredients; low ration, $50.04, medium ration, $56.76.

Difference in favor of medium ration, $6.72.

Gain ($6.72), less extra cost, ($5.88), gives net gain, $0.84; daily net gain, 0.58 cents.

RATIONS	Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Buffalo gluten or buckwheat middlings	Milk	Butter	Money value of food	Cost of food for 100 lbs. of milk	Cost of food for 1 lb. butter	Proceeds for butter at 20 cents	Fertilizing value of food eaten
108 DAYS ON LOW RATION VS. 108 DAYS ON MEDIUM RATION (NO. 2, BUFFALO GLUTEN, BRAN)													
Low	1340	2797	....	144	....	284	1996	118	15.35	76.9	13.0	23.60	9.66
Medium	1314	2901	....	278	....	557	2175	133	19.60	90.1	14.7	26.60	12.37
Differences in favor of medium ration							+179	+ 15	+ 4.25	+13.2	+ 1.7	+ 3.00	+ 2.71
Percentage differences							+ 9	+ 13	+ 28	+ 17	+ 13	+ 13	+ 28

Total value of butter, skimmilk and two-thirds of fertilizing ingredients; low ration, $33.46, medium ration, $38.57.

Difference in favor of medium ration, $5.11.

Gain, ($5.11), less extra cost, ($4.25), gives net gain, $0.86; daily net gain, 0.80 cents.

RATIONS	Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Buffalo gluten or buckwheat middlings	Milk	Butter	Money value of food	Cost of food for 100 lbs. of milk	Cost of food for 1 lb. butter	Proceeds for butter at 20 cents	Fertilizing value of food eaten
126 DAYS ON LOW RATION VS. 126 DAYS ON MEDIUM RATION (NO. 3, BUCKWHEAT MIDDLINGS AND BRAN)													
Low	1345	3851	....	168	....	336	2311	149	17.58	76.1	11.8	29.80	11.83
Medium	1322	3727	....	333	....	663	2385	161	22.23	93.2	13.8	32.20	15.57
Differences in favor of medium ration							+ 74	+ 12	+ 4.65	+17.1	+ 2.0	+ 2.40	+ 3.74
Percentage differences							+ 3	+ 8	+ 26	+ 23	+ 17	+ 8	+ 32

Total value of butter, skimmilk and two-thirds of fertilizing ingredients; low ration, $41.64; medium ration, $46.65.

Difference in favor of medium ration, $5.01.

Gain, ($5.01), less extra cost, ($4.65), gives net gain, $0.36; daily net gain, 0.29 cents.

RATIONS	Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Buffalo gluten or buckwheat middlings	Milk	Butter	Money value of food	Cost of food for 100 lbs. of milk	Cost of food for 1 lb. butter	Proceeds for butter at 20 cents	Fertilizing value of food eaten
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	$	cts.	cts.	$	$

378 DAYS ON LOW RATION VS. 378 DAYS ON MEDIUM RATION (NOS. 1, 2 AND 3, ALL THREE RATIONS)

Low	4591	11690	72	600	216	284 336	7687	438	56.10	73.0	12.8	87.60	36.56
Medium	4517	11622	144	1187	432	557 663	8213	482	70.88	86.3	14 7	96.40	47.33
Differences in favor of medium ration							+526	+ 44	+14.78	+13.3	+ 1.9	+ 8.80	+10.77
Percentage differences							+ 7	+ 10	+ 26	+ 18	+ 15	+ 10	+ 29

Total value of butter, skimmilk and two-thirds of fertilizing ingredients; low ration, $125.12; medium ration, $142.01.

Difference in favor of medium ration, $16.89.

Gain ($16.89), less extra cost, ($14.78), gives net gain, $2.11; daily net gain, 0.56 cents.

72 DAYS ON LOW RATION VS. 72 DAYS ON HIGH RATION (NO. 1, COTTONSEED, LINSEED, CORN AND BRAN)

Low	851	2472	36	144	108	.....	1525	88	11.01	72.2	12.5	17.60	7.16
High	892	2177	108	427	322	.....	1898	104	16.77	88.3	16.1	20.80	11.40
Differences in favor of high ration							+373	+ 16	+ 5.76	+16.1	+ 3.6	+ 3.20	+ 4.24
Percentage differences							+ 24	+ 18	+ 52	+ 22	+ 29	+ 18	+ 59

Total value of butter, skimmilk and two-thirds of fertilizing ingredients; low ration, $24.98; high ration, $31.65.

Difference in favor of high ration, $6.67.

Gain, ($6.67), less extra cost, ($5.76), gives net gain, $0.89; daily net gain, 1.24 cents.

90 DAYS ON LOW RATION VS. 90 DAYS ON HIGH RATION (NO. 2, BUFFALO GLUTEN AND BRAN)

Low	1132	2368	....	120	....	237	1690	102	12.92	76.5	12.7	20.40	81.2
High	1096	2238	....	331	....	662	2000	120	19.17	95.9	16.0	24.00	12.12
Differences in favor of high ration							+310	+ 18	+ 6.25	+19.4	+ 3.3	+ 3.60	+ 4.00
Percentage differences							+ 18	+ 18	+ 48	+ 25	+ 26	+ 18	+ 49

Total value of butter, skimmilk and two-thirds of fertilizing ingredients; low ration. $28.71; high ration, $35.50.

Difference in favor of high ration, $6.79.

Gain ($6.79), less extra cost, ($6.25), gives net gain $0.54; daily net gain, 0.60 cents.

RATIONS	Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Buffalo gluten feed	Milk	Butter	Money value of food	Cost of food for 100 lbs. of milk	Cost of food for 1 lb. butter	Proceeds for butter at 20 cents	Fertilizing value of food eaten
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	$	cts.	cts.	$	$

162 DAYS ON LOW RATION VS. 162 DAYS ON HIGH RATION (NOS. I AND 2, COTTONSEED-LINSEED; BUFFALO GLUTEN*)

RATIONS	Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Buffalo gluten feed	Milk	Butter	Money value of food	Cost of food for 100 lbs. of milk	Cost of food for 1 lb. butter	Proceeds for butter at 20 cents	Fertilizing value of food eaten
Low	1983	4840	36	264	108	237	3215	189	23.93	74.4	12.7	37.80	15.30
High	1988	4415	108	758	322	662	3898	224	35.94	92.2	16.0	44.80	23.52
Differences in favor of high ration							+683	+ 35	+12.01	+17.8	+ 3.3	+ 7.00	+ 8.22
Percentage differences							+ 21	+ 19	+ 50	+ 24	+ 26	+ 19	+ 54

Total value of butter, skimmilk and two thirds of fertilizing ingredients; low ration, $53.51; high ration, $67.13.

Difference in favor of high ration, $13.62.

Gain ($13.62), less extra cost, ($12.01), gives net gain, $1.61; daily net gain, 0.99 cents.

* No comparison of low and high grain feeding on mixed feed No. 3 could be made, the sequence of the periods being such as to preclude it.

198 DAYS ON MEDIUM RATION VS. 198 DAYS ON HIGH RATION (NO. I, COTTONSEED, LINSEED, CORN AND BRAN)

RATIONS	Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Buffalo gluten feed	Milk	Butter	Money value of food	Cost of food for 100 lbs. of milk	Cost of food for 1 lb. butter	Proceeds for butter at 20 cents	Fertilizing value of food eaten
Medium	2178	6430	193	772	575	-----	4560	251	36.76	80.6	14.6	50.20	24.57
High	2263	5732	276	1107	832	-----	5168	274	43.28	83.7	15.8	54.80	29.42
Differences in favor of high ration							+608	+ 23	+ 6.52	+ 3.1	+ 1.2	+ 4.60	+ 4.85
Percentage differences							+ 13	+ 9	+ 18	+ 4	+ 8	+ 9	+ 20

Total value of butter, skimmilk and two-thirds of fertilizing ingredients; medium ration, $74.38; high ration, $83.25.

Difference in favor of high ration, $8.87.

Gain ($8.87), less extra cost ($6.52), gives net gain, $2.35; daily net gain, 1.19 cents.

180 DAYS ON MEDIUM RATION VS. 180 DAYS ON HIGH RATION (NO. 2, BUFFALO GLUTEN AND BRAN)

RATIONS	Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Buffalo gluten feed	Milk	Butter	Money value of food	Cost of food for 100 lbs. of milk	Cost of food for 1 lb. butter	Proceeds for butter at 20 cents	Fertilizing value of food eaten
Medium	2255	5264	----	465	----	930	3960	250	33.68	85.1	13.5	50.00	21.22
High	2347	4677	----	677	----	1355	4262	262	39.90	93.6	15.2	52.40	25.21
Differences in favor of high ration							+302	+ 12	+ 6.22	+ 8.5	+ 1.7	+ 2.40	+ 3.99
Percentage differences							+ 8	+ 5	+ 18	+ 10	+ 13	+ 5	+ 19

Total value of butter, skimmilk and two-thirds of fertilizing ingredients; medium ration, $70.92; high ration, $76.49.

Difference in favor of high ration, $5.57.

Gain ($5.57), less extra cost, ($6.22), gives net loss, $0.65; daily net loss, 0.36 cents.

RATIONS	Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Buffalo gluten or buckwheat middlings	Milk	Butter	Money value of food	Cost of food for		Proceeds for butter at 20 cents	Fertilizing value of food eaten
										100 lbs. of milk	1 lb. butter		
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	$	cts-	cts.	$	$
54 DAYS MEDIUM RATION VS. 54 DAYS ON HIGH RATION (NO. 3, BUCKWHEAT MIDDLINGS AND BRAN)													
Medium	595	1520	....	143	....	286	1082	73	9.58	88.5	13.1	14.60	6.72
High	601	1432	....	198	....	395	1119	78	11.13	99.4	14.3	15.60	7.98
Differences in favor of high ration							+ 37	+ 5	+ 15.5	+10.9	+ 1.2	+ 1.00	+ 1.26
Percentage differences							+ 4	+ 7	+ 16	+ 12	+ 9	+ 7	+ 19

Total value of butter, skimmilk and two-thirds of fertilizing ingredients; medium ration, $20.93 ; high ration, $22.84.

Difference in favor of high ration, $1.91.

Gain ($1.91), less extra cost, ($1.55), gives net gain, $0.36 ; daily net gain 0.67 cents.

RATIONS	Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Buffalo gluten or buckwheat middlings	Milk	Butter	Money value of food	Cost of food for 100 lbs. of milk	Cost of food for 1 lb. butter	Proceeds for butter at 20 cents	Fertilizing value of food eaten
432 DAYS ON MEDIUM RATION VS. 432 DAYS ON HIGH RATION (NOS. 1, 2 AND 3, ALL THREE RATIONS)													
Medium	5028	13214	193	1380	575	930 286	9602	574	80.02	83.3	13.9	114.80	52.53
High	5211	11841	276	1982	832	1355 395	10549	614	94.30	89.4	15 4	122,80	62.59
Differences in favor of high ration							+947	+40	+14.28	+ 6.1	+ 1.5	+ 8.00	+10.06
Percentage differences							+ 10	+ 7	+ 18	+ 7	+ 11	+ 7	+ 19

Total value of butter, skimmilk and two-thirds of fertilizing ingredients; medium ration, $166.25 : high ration, $182.60.

Difference in favor of high ration, $16.35.

Gain ($16.35), less extra cost, ($14.28), gives net gain, $2.07 ; daily net gain, 0.48 cents.

The following deductions seem warranted by the data in the foregoing tables:[1]

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[1] It should be noted in this connection that the prices used for roughage are relatively high, considerably larger than those often used in calculations of this character. It is also to be observed that the prices for grain are higher than in the west, and higher than of recent years. These factors serve to increase calculated cost and to decrease or, perhaps, obliterate profits. As the comparisons have only relative values, however, this is not a serious matter. It is referred to in order to forestall possible criticism as to the high cost for food of making a pound of butter. It would be easy to "figure" much cheaper milk and butter.

1. *Low and medium grain feeding.*—When the sundry rations used in this experiment were fed with hay and silage at the rate of 8 pounds daily instead of 4 pounds daily, from 3 to 9 percent more milk was made, and from 8 to 13 percent more butter and money. The average results were 7 percent more milk and 10 percent more butter. The cost for feed of making this extra product was found to be 26 percent greater. It cost on the average 18 percent more to make a pound of milk and 15 percent more to make a unit of butter. There was of course more skim milk made on the more liberal ration, and it contained on the average 29 percent more fertilizing ingredients. When these two items are reckoned in, the medium ration leads; if the increase of butter only is considered, the lower ration proved better, in that the increase in butter did not compensate for the extra cost of the grain. Using average figures only, the daily feeding of 4 pounds more grain for 378 days entailed an extra cost of $14.78, and an added butter yield worth $8.80, or a loss of $5.98. It also made 450 pounds more skimmilk and better manure. If the former be valued at 20 cents and two-thirds[1] of the latter is reckoned at the prices stated in the footnote on page 409, there is a gain of $8.09 as an offset against the loss of $5.98, a net gain of $2.11, or a daily net gain of 0.56 cents for each cow, as a result of feeding 8 pounds of grain daily instead of 4 pounds.

2. *Low and high grain feeding.*—When the first two rations used in this experiment were fed with hay and silage at the rate of 12 pounds daily instead of 4 pounds daily, there was made 21 percent more milk and 19 percent more butter and money, at, however, an added cost for feed of 50 percent. This naturally augmented the cost of making a unit of milk and of butter, the increases being 24 and 26 percent respectively. The extra fertilizing ingredients "valued" 54 percent more. If two-thirds of these and the increased skimmilk are reckoned in, the higher feeding proved superior, but, as in the case of the low and medium comparison, not otherwise. The daily feeding of 8 pounds more grain for 162 days cost $12.01 more and made only $7.00 worth more butter, a loss of $5.01. Adding in the skim milk and manurial increase, however, there is an offset of $6.62, a net gain of $1.61, or a daily net gain for each cow of 0.99 cents as a result of feeding 12 pounds of grain daily instead of 4 pounds.

3. *Medium and high grain feeding.*—When the sundry rations used in these feeding trials were fed with hay and silage at the rate of 12 pounds daily instead of 8 pounds daily there was made from 4 to 13 percent more milk, from 5 to 9 percent more butter and money. It cost, however, from 16 to 18 percent more to make the milk and butter, from 4 to 12 percent more to make a quart of milk and from 8 to 13 percent more to make

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[1] It is uncertain how much of the plant food may reach the soil. This depends on many factors. It is conservative to allow two-thirds as ultimately available.

a pound of butter. The extra skimmilk and manurial value enter into the problem as before. When these are allowed for, the heavier feeding paid; if they are not considered, it was not a success. The daily feeding of 4 pounds more grain for 432 days cost $14.28 more and made but $8.00 worth more butter, a loss of $6.28. The increase in skimmilk and in manurial value, reckoned as before, form an offset of $8.35, a net gain of $2.07, or a daily net gain for each cow of 0.48 cents, as a result of feeding 12 pounds grain daily instead of 8 pounds.

The salient points of the tables on pages 410-413 and of the discussion following the same are given below. The table shows the days of feeding on each ration, the added cost for feed of the higher grade ration, the net gain from butter sales, the net loss when these alone are considered as an asset, the value of the skimmilk and of two-thirds of the manurial ingredients, the net gain from butter, skimmilk and manure and the net gain from feeding one cow for one day.

RELATIVE VALUE OF THE THREE GRAIN RATIONS, LOW, MEDIUM AND HIGH FEEDING

	Medium better than low ration	High better than low ration	High better than medium. ration
Days of feeding on each ration	378	162	432
Cost of added grain feed	$14.78	$12.01	$14.28
Net gain from butter sales @ 20 cents	$ 8.80	$ 7.00	$ 8.00
Net loss, i.e. cost of additional grain less value of butter	$ 5.98	$ 5.01	$ 6.28
Value of skimmilk and of two-thirds manurial ingredients	$ 8.09	$ 6.62	$ 8.35
Net gain from butter, skimmilk and manure	$ 2.11	$ 1 61	$ 2.07
Net gain from one day's feeding of one cow	0.56 cents	0.99 cents	0.48 cents

4. *Does heavy grain feeding pay?*—It depends. Given good cows of mature years, 8 pounds daily of a well chosen grain ration is probably to be preferred to 4 pounds daily, or, indeed, to 6 pounds. If butter production alone is taken into account the verdict of these trials, so far as it goes, is emphatically and every time in favor of relatively light grain feeding.

It is, as a broad and general rule, inadvisable in any branch of manufacturing industry to spend more in producing an extra unit than that unit will return in money. Yet sometimes, in order to make the material already on hand available, money is spent at an actual loss. Similarly in dairy feeding, a moderately liberal grain ration may tend to make the farm roughages more available. If 4 pounds of grain were really more economical than 8 pounds, and 8 pounds than 12, then, *reductio ad absurdum*, 0 pounds would be found more profitable than 4 pounds. It should be borne in mind, moreover, that long continued low pressure feeding will not be apt to work as well as in four week periods, since the cow perhaps is able to recuperate during periods when better fed. The trials of the present winter (1900-1901) are planned with a view of endeavoring to measure, so far as may be, these secondary effects.

It should be said, moreover, that in these days the byproducts in every industry are extremely important. Many a corporation loses money on its main output and pays its dividends from the income derived from the sale of byproducts. The very grain feeds the farmer buys are the byproducts of the milling companies. More skimmilk and better manure will go far towards paying the cost of extra grain, leaving, at any rate, some of the increase of butter as profit. It should be remembered, moreover, that the cow which has to make considerable quantities of butter on a small grain ration is apt either to fail in her endeavor or to make it at the expense of live weight and vigor of constitution. A fairly liberal grain ration tends, moreover, to prolong the milking period and thus to add to the profits in a manner which these trials do not show.

If 8 pounds is good will 12 pounds prove better? Is very heavy feeding advisable? Looking at the matter purely from the financial standpoint it seems to have been as well worth while in the present trials to raise the daily grain ration from 8 to 12 pounds as from 4 to 8 pounds. In the former case the butter increase for a hundred days feeding was 9.26 pounds, and in the latter case, 11.64 pounds. But it may well be queried what the effect of prolonged feeding of high grain rations will be upon the constitution of the cow. It is not uncommon for cows to wear out more rapidly under such forced production than when less heavily fed. The dairyman who decides to adopt such rations should carefully consider his cows and his markets before he dips so deeply into the grain bin.

The results obtained in the Wisconsin trials are of interest in this connection. The plan of operation was quite different from that employed at this station. Eight cows were used in the first and 16 in the second trial. Hay, silage, corn meal, ground oats and linseed meal were fed to all the cows each year. The cows were fed either 8 or 12 pounds daily of the grain feed. The cows were divided as nearly as might be into two even lots, one of which remained on the 8 pound ration for twelve weeks, while the other was thus fed during the first and last four weeks of this time, shifting to 12 pounds in the intervening four weeks. The ration was considerably wider than that used at this station. The outcome of the two years' work agrees in general with that of the trials reported herewith. Heavier grain feeding resulted in increased yield of milk and butter, but at a disproportionate cost. The cost to the unit of product was greatly increased; and the heavier ration did not help the yield in the subsequent two months of milking. No account was taken of the byproducts or of manurial values. It is stated that "the results * * * lead to the conclusion that it does not pay to feed dairy cows more than a medium amount of grain feed, which may be placed at about eight pounds per head daily, except in cases of cows of marked dairy tendencies that respond to heavy grain feeding by an increased production of milk and fat rather than by a gain in live weight."

IV. THE ADDITION TO A RATION OF EXCESSIVE AMOUNTS OF SINGLE NUTRIENTS

It is held that a normal ration for a dairy cow should carry certain more or less well defined proportions of the sundry digestible nutrients. Thus the Wolff ration prescribes for a thousand pound cow's daily ration 2.5 pounds protein, 12.5 pounds carbohydrates and 0.4 pounds fat, all in digestible forms. What would be the effect upon the cow and her product if any one of these was greatly increased? If 4 pounds protein, or 18 pounds carbohydrates, or over a pound of fat were fed daily? Would the extra protein, which is thought to be a "milk stimulant," mean more milk? Would more digestible carbohydrates—the nutrient which Jordan's[1] work has indicated is the main source of the milk fat—increase the butter yield? Will a fluid or a solid fat added to the ration affect the milk flow in any way?

No single series of feeding trials can at most do more than accumulate data for the final answering of these questions; and no more than this is claimed for the present series.

GENERAL PLAN

It was planned to feed to each of nine cows a basal ration of hay, silage and mixed feed No. 1 in sufficient quantities to afford rather more than standard (Wolff-Lehmann) amounts of nutrients. The ration had a nutritive ratio approximating 1:5.7. To this ration was added in the second, fourth and sixth periods one or the other of the three nutrients. Thus, in the second period, protein[2] was added to the rations of three of the nine cows, a carbohydrate to those of three others, and a solid fat to those of three others. In the fourth period the same thing was done except that the cows which received protein in the second period were given the carbohydrate in the fourth, those receiving the carbohydrate in the second period got fat, and those getting fat formerly received protein. A similar shift was made in the sixth period. The unaltered basal ration was fed in the first, third, fifth and seventh periods.

Atlantic gluten flour, a byproduct of starch works, carrying, as fed, 81 percent of crude protein; brown sugar, testing, as fed, 94.5 percent of dry matter and 88 percent sugars ; and palm oil, containing 98 percent fat, were chosen to effect the desired additions, and were fed, when maximum amounts were used, at the rates respectively of one and one-half, three and three-fourths pounds daily. The sugar was eaten without waste ; the gluten flour was left somewhat by one cow ; the palm oil was relished by none, quite closely eaten by some and considerably left by others. All three nutrients were added in the meal. One cow in addition to the nine was fed the Atlantic gluten flour in three of five feeding periods.

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[1] N. Y. (State) Sta. Bul. 132 (1898).

[2] A material of high protein content; pure protein as such was unattainable.

CHOICE OF COWS

Ten cows were used in this test. Six were fresh in milk, three were two months and one, three months along in lactation. Two remained unserved throughout the trials ; two of the others were put to the bull in December, one in February, the remainder well on towards the close of the trials. Six of the cows were four years old, three were more mature and one was a three year-old. The lot as a whole were in many ways the pick of the herd as it stood in the late fall ; that is to say of the entire 53 cows they appeared best adapted to this purpose and were undoubtedly as good a lot for experimental purposes as has hitherto been gotten together at this station.

COMPARISON WITH STANDARDS[1]

Wolff.[1]—All the cows ate much more total and digestible[2] nutrients than the standard calls for. The lighter cows ate enough for animals 200 pounds heavier and the larger ones, for cows 100 pounds heavier. When sugar was added the eating was correspondingly excessive. When oil was fed the ration dropped nearer to standard. Protein was always eaten in excess and carbohydrates generally so. The heavier cows, however, did not eat much more of the latter than standard requirements.

Wolff-Lehmann.[1]—The same general statements made concerning comparison with the Wolff standard hold here, more food being eaten than standards required.

RESULTS

The following table, transcribed from table VI (*b*), in the appendix shows the increase or decrease—expressed as percentages, total equaling 100—in dry matter eaten, in milk, total solids and fat given, and of products per 100 pounds of dry matter eaten, both in the total ration and in the experimental portions thereof when (*a*) protein, (*b*) a carbohydrate, (*c*) fat, respectively, were added to the ration; hay and silage as roughages and mixed feed No. 1 as concentrate being fed throughout, nutritive ratios ranging from 1:5.0 to 1:6.2 and averaging 1:5.5 when the regular ration was eaten; from 1:3.8 to 1:5.0 and averaging 1:4.4 when protein was added; from 1:6.1 to 1:6.9 and averaging 1:6.5 when a carbohydrate was added; and from 1:5.8 to 1:6.7 and averaging 1:6.1 when fat was added to the ration.

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[1] See footnote. page 405.

[2] Obviously assumptions had to be made as to the digestibility of the gluten flour, sugar and palm oil. No data whatever are at hand showing the digestibility of the flour and the oil. It seemed reasonable to assume the digestion coefficients of gluten meal for the flour, and to call all the sugar and 80 per cent of the fat digestible ; and these assumptions were made. The digestible ingredients eaten as shown in the tables in the appendix, as well as the deductions drawn therefrom, are on this account open to more or less error.

TRANSCRIPT FROM DIFFERENCE TABLES,[1] ETC. (APPENDIX VI (*b*))

RATIONS	Dry matter	Dry matter in experimental feed	Quantity of milk	Total solids, per cent	Fat, per cent	Quantity of total solids	Quantity of fat	Product per 100 lbs. of dry matter					
								Entire ration			Experimtl. feed		
								Milk	Total solids	Fat	Milk	Total solids	Fat
M. F. 1+ gluten (actual) ± M. F. 1 (calculated)	+ 2	+ 9	+3	0	0	+3	+3	+1	+1	+ 1	− 5	− 5	− 5
M. F. 1+ sugar (actual) ± M. F 1 (calculated)	+10	+45	+2	0	0	+2	+1	−8	−8	− 8	−30	−30	−30
M. F. 1+ fat (actual) ± M. F. 1 (calculated)	− 2	0	+2	+2	+7	+3	+9	+3	+5	+11	0	+2	+ 8

CONCLUSIONS

1. *Protein.*—The addition of protein (Atlantic gluten flour) to a ration containing amounts of this nutrient greater than standard requirements had at most but a slight effect on the quantity and none upon the quality of the milk flow. Five of the nine[2] animals gave from 4 to 9 percent more milk, three the same and one 8 percent less milk on the richer ration. Four gave from 1 to 11 percent more milk and five from 2 to 11 percent less milk to the unit of digestible dry matter. It seems clear that in this experiment the extra protein was without effect as a milk stimulant.

2. *Carbohydrates.*—The addition of considerable quantities (10 percent of the total dry matter) of a carbohydrate (cane sugar) to a ration containing amounts of this nutrient in digestible forms equal to or in excess of the requirements of either the Wolff or the Wolff-Lehmann standards, had but a slight effect, if any, upon the quantity and none upon the quality of the milk flow. But one of seven[3] cows gave as much as 5 percent more milk

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[1] See footnote, page 406.

[2] One cow came in too late to admit of the use of the data she afforded on gluten feeding.

[3] Two cows came in too late for use in the sugar trials.

and six of the seven gave much less milk, total solids and fat to the unit of dry matter eaten[1]. In this particular trial the large addition of a digestible and palatable carbohydrate to a ration already well supplied therewith was without effect upon the milk flow.

3. *Fat.*—The addition of a solid fat (palm oil) to a ration containing amounts of this nutrient in digestible forms in excess of the requirements of either the Wolff or the Wolff-Lehman standards had perhaps a slight effect upon the milk yield. It had a pronounced effect upon the quality of the flow, increasing the total solids 2 percent (0.24 percent) and the fat 7 percent (0.36 percent). The increase appears to have been a permanent one. Seven of the nine cows averaged 0.24 percent increase in the fat content of the milk during the first ten days on palm oil, when but little was fed in order gradually to accustom the cows to the strange diet. These same cows during the last eighteen days (experimental period) averaged 0.20 percent more increase in the fat on top of the 0.24 percent already given, or 0.44 percent in all over the figures of the preceding period in which no palm oil was fed. And these seven cows dropped 0.40 percent fat during the ten days following the withdrawal of the palm oil from the ration, and recovered less than one-third of this (0.12 percent) in the following 18 days. Of the other two cows, one did not better the quality of the milk until the preliminary period was finished and the new ration was well established. It was then increased 0.27 percent in fat. The other cow gave poorer milk during the preliminary portion and normal quality during the experimental portion of the period on the heartier fat feeding.

In somewhat similar trials reported last year[2] cottonseed oil was found to increase the fat content of milk permanently[3] to an extent of 0.20 to 0.30 percent. Emulsified corn and linseed oils depressed the fat percentages.

Financial considerations obviously did not enter into this particular series of trials. The protein, carbohydrate and fat, added in the form of gluten flour, sugar and palm oil, were relatively very expensive, and the ration on that account excessively costly. They were used, as has been hitherto pointed out, for other than economical reasons. No attempt is made, therefore, to sum up the financial outcome of these trials.

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[1] The exception was due to the coincidence of a lessened silage ration and the sugar feeding, resulting in no increase in the total dry matter eaten.

[2] Vt. Sta. Rpt. 12 pp. 269-275 (1899).

[3] Up to five weeks, the close of the period.

V. THE FEEDING VALUE OF BUCKWHEAT MIDDLINGS

The buckwheat byproducts are widely variable in composition. The true middlings contain much and the hulls little protein, while the so-called bran is apt to be somewhat of a nondescript. The middlings as sold are far more variable in their character than are the byproducts of other milling industries; and the buyer of such may be getting either a rich or a rather low grade of goods. This is due to the admixture of more or less hull in the middlings.

The cut on page 422[1] shows a cross section of the buckwheat seed and hull. The outer and inner hull coatings (*a-d*) are largely of a fibrous nature, and contain but little protein. Layers *e* and *f* with more or less of *g* form, or should form, the true middlings. The hulls (*a-d*) contain about 6 percent, the middlings, (*e*, *f*, and some of *g*) 28 percent or more of crude protein.

The milling products are:

1. The flour; *g*. with as little of the other layers as is practicable.
2. The middlings; *e*. and *f*. with more or less of *g*. Sometimes through carelessness, ignorance or intent, *c*. and *d*. enter into this material to some extent. It is just this condition of affairs which makes the middlings so variable in their character.
3. The hulls; *a*. to *d*. inclusive.

The term "bran" is not infrequently used to cover a nondescript admixture of hulls and middlings.

The value of buckwheat middlings as a dairy feed is not well established. Some feeders approve, others dislike it. It is not unlikely that the variation alluded to accounts somewhat for this difference of opinion.

A test of these goods was reported last year. Repetition was made this year with a much richer lot of middlings.

FEEDING

Five cows were used in the test. One, however, refused to eat enough middlings to make the results trustworthy. A second "balked up" on the rich diet late in the test, but, happily, so late that the results of five periods are satisfactory. Hay and silage were fed to all the cows. Two ate alternations of mixed feed No. 1 and clear buckwheat middlings; the other two, of corn and bran and clear buckwheat middlings.

COMPARISON WITH STANDARDS[2]

Wolff.—Total and digestible dry matter and all nutrients were eaten in excess of requirements, except that when corn and bran was fed protein was lacking in Buttercup's ration. Serena's protein supply, however, was up to standard when she was thus fed.

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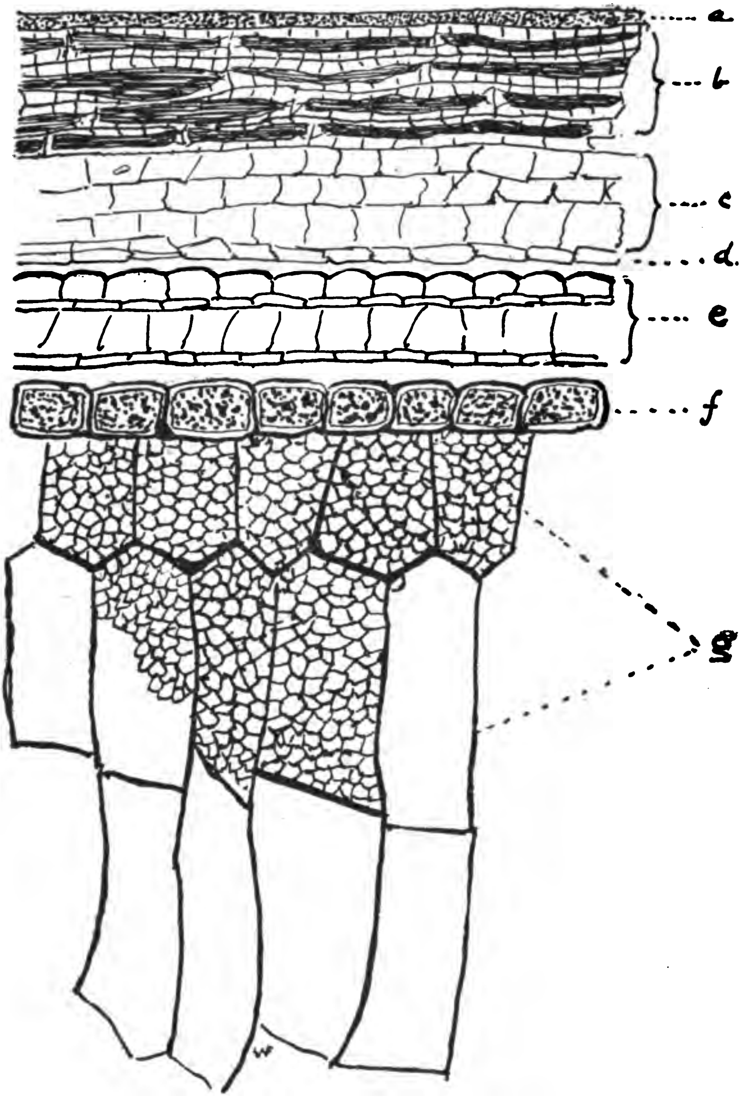
[1] From Pa. Sta. Rpt. (no vol.), p. 171, (1899).

[2] See footnote on page 405.



CROSS SECTION OF BUCKWHEAT SEED AND HULL

Redrawn from Harz. Ldw. Samenkunde, p. 1103

The seven distinct layers are :

a. The outer epidermis or skin of the hull.
b. A woody layer.
c. A less hardened layer.
d. The inner epidermis or skin of the hull.
e. The true coating of the seed.
f. The aleurone cells ; these in all seeds are located just beneath the true seed coat and are rich in protein.
g. The starchy cells or endosperm of the grain, from which the flour is made.

Wolff-Lehmann.—The remarks made as to conformity with the Wolff standard apply here, save that the protein eaten was equal to or greater than standard in all cases. These cows were fed the food prescribed for animals much heavier than they and they gained in live weight.

RESULTS

The results of these tests are grouped in two tables, the first showing the outcome when the cottonseed-linseed mixture was fed, the second where corn and bran were used.

The following table[1] summarized from various points in the appendix, shows the increase or decrease—expressed as percentages, total equaling 100—in dry matter eaten, milk, total solids and fat given, and of products per 100 pounds of dry matter, both in the total ration and in the experimental portion thereof, when a grain mixture containing corn meal, wheat bran, cottonseed and linseed meals (No. 1)—nutritive ratios ranging from 1:5.3 to 1:6.2 and averaging 1:5.8—was fed in place of buckwheat middlings, nutritive ratios ranging from 1:5.1 to 1:6.2 and averaging 1:5.5, or vice versa; hay and silage being fed as roughages throughout.

SUMMARY OF DIFFERENCE TABLES,[1] ETC. (APPENDIX VI (*b*) AND VII)

RATIONS	Total dry matter eaten	Dry matter eaten in concentrates	Quantity of milk	Total solids, per cent	Fat, per cent	Quantity of total solids	Quantity of fat	Products per 100 pounds of dry matter						Ratio of fat to solids-not-fat
								In entire ration			In experimental feed			
								Milk	Total solids	Fat	Milk	Total solids	Fat	
(*a*) Buckwheat middlings ± mixed feed No. 1	− 1	−10	−4	+1	+4	−3	+1	−2	−1	+ 2	+ 7	+ 9	+12	
(*b*) Mixed feed No. 1 ± buckwheat middlings	+ 2	+13	+4	−1	−3	+3	0	+2	+1	− 1	− 8	− 9	−12	
(*c*) 162 days on mixed feed ± 162 days on buckwheat middlings	+ 1	+12	+4	−1	−4	+3	0	+2	+1	− 2	− 7	− 9	−11	+2

The following table,[1] summarized from various points in the appendix, shows the increase or decrease—expressed as percentages, total equaling 100—in dry matter eaten, milk, total solids, and fat given, and of products per 100 pounds of dry matter, both in the total ration and in the experimental portion thereof, when a grain ration containing corn meal and wheat

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[1] See footnote, page 406.

bran (No. 4)—nutritive ratios ranging from 1:8.2 to 1:9.5 and averaging 1:8.8—was fed in place of buckwheat middlings, nutritive ratios ranging from 1:4.6 to 1:7.0, and averaging 1:5.7, or vice versa; hay and silage being fed as roughages throughout.

SUMMARY OF DIFFERENCE TABLES,[1] ETC. (APPENDIX VI (*b*) AND VII)

RATIONS	Total dry matter eaten	Dry matter eaten in concentrates	Quantity of milk	Total solids, per cent	Fat, per cent	Quantity of total solids	Quantity of fat	Products per 100 pounds of dry matter						Ratio of fat to solids-not-fat
								In entire ration			In experimental feed			
								Milk	Total solids	Fat	Milk	Total solids	Fat	
(*a*) Buckwheat middlings ± corn and bran	− 5	−14	+3	+1	+4	+4	+7	+8	+9	+13	+21	+23	+27	
(*b*) Corn and bran ± buckwheat middlings	+ 4	+13	−4	0	−2	−4	−1	−7	−7	− 9	−16	−16	−18	
(*c*) 162 days feeding on corn and bran ± 162 days feeding on buckwheat middlings	+ 5	+15	−3	−1	−3	−4	−6	−8	−9	−10	−17	−18	−20	+4

CONCLUSIONS

1. A unit of dry matter in the cottonseed-linseed mixture produced 2 percent more milk, 1 percent more total solids and 1 percent less fat than in the buckwheat middlings mixture.

2. A unit of dry matter in the buckwheat middlings mixture produced about 8 per cent more milk and total solids and 11 per cent more fat than in the corn and bran ration.

3. The quality of the milk was decidedly affected, there being in both cases disproportionate increase in the fat content of the milk when the buckwheat byproduct was fed. The milk made on buckwheat middlings contained nearly 0.20 percent more fat than did that made on either the cottonseed-linseed or the corn and bran mixture. A similar result was noted in last year's feeding of clear buckwheat middlings, although the result, for reasons cited, was not above criticism. The present data, however, seem trustworthy.

Buckwheat middlings, cerealine feed and brewers' grains have been reported to have essentially equal feeding values.[2] The two years' results at this station seem to rank the first named feed well above equal parts of corn and bran and rather below a mixture in which cottonseed and linseed meals make up three-eighths, bran one-half and corn meal one-eighth the weight. It should be remembered, however, that cows do not as a rule relish it fed clear; and that in normal feeding it is better fed mixed with other feeds. This fact was thoroughly appreciated in planning the experiment; but as it was desirable to make results as clear cut as possible, the unmixed middlings were used.

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[1] See footnote, page 406.

[2] Hayward and Weld, Pa. Sta. Rpt. (no vol.), pp. 51-64 (1897).

FINANCIAL CONSIDERATIONS

The dollars-and-cents outcome of these tests is summarized in the following table and comments. The table is of the same general character as those appearing on pages 410-413, and the descriptive and explanatory remarks preceding those tables apply here as well.

COMPARATIVE VALUES OF VARIOUS RATIONS FROM THE FINANCIAL STANDPOINT

RATIONS	Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Buckwheat middlings	Milk	Butter	Money value of food	Cost of food for		Proceeds for butter at 20 cents	Fertilizing value of food eaten
										100 lbs. of milk	1 lb. butter		
	lbs.	lbs.	lbs	lbs.	lbs.	lbs.	lbs.	lbs.	$	cts.	cts.	$	$
162 DAYS ON BUCKWHEAT MIDDLINGS RATION VS. 162 DAYS ON COTTONSEED, LINSEED, CORN AND BRAN RATION (8 LBS. DAILY EACH RATION)													
Buckwheat middlings....	2177	5788	3	3	....	1095	3305	200	31.20	94.4	15.6	40.00	22.23
Cottonseed, etc............	2194	5623	162	642	482	....	3442	199	32.97	95.8	16.6	39.80	21.96
Difference in favor of buckwheat middlings..							−137	+ 1	−1.77	−1.4	−1.0	+0.20	+0.27
Percentage differences. ..							− 4	0	− 6	− 1	− 6	+ 1	+ 1

Total value of butter, skimmilk and two-thirds of manurial ingredients; buckwheat middlings ration, $60.49, cottonseed, etc., ration, $60.35.

Difference in favor of buckwheat ration, $0.14.

Gain ($0.14), plus lessened cost ($1.77), gives net gain, $1.91; daily net gain, 1.18 cents.

162 DAYS ON BUCKWHEAT MIDDLINGS RATION VS. 162 DAYS ON CORN AND BRAN RATION (8 LBS. DAILY EACH RATION)

Buckwheat middlings	1726	4744	3	101	....	874	2455	164	25.93	105.6	15.8	32.80	18.40
Corn and bran............	1735	4890	576	576	....	....	2377	154	26.38	111.0	17.1	30.80	14.90
Difference in favor of buckwheat middlings...							+ 78	+10	−0.45	−5.4	−1.3	+2.00	+3.50
Percentage differences....							+ 3	+ 6	− 2	− 5	− 8	+ 6	+ 19

Total value of butter, skimmilk and two-thirds manurial ingredients; buckwheat middlings ration, $49.27, corn and bran ration, $44.80.

Difference in favor of buckwheat middlings ration, $4.47.

Gain ($4.47), plus lessened cost ($0.45), gives net gain, $4.92; daily net gain, 3.04 cents.

The following deductions seem warranted by the data in these tables:

1. The buckwheat middlings ration fed with hay and silage 162 days as compared with the cottonseed-linseed ration fed a similar time, cost 6 percent less and made 4 percent less milk but the same amount of butter, the milk being somewhat richer. It consequently made cheaper milk and considerably cheaper butter. The fertilizing value of the two rations was about the same. This resulted—using the assumptions hitherto explained on page 414—in a gain of $0.14 which, taken together with the lessened cost, made a net gain in favor of the buckwheat ration of $1.91 and a daily net gain of 1.18 cents.

In the experiments of last year the result was a balance between the two rations as regards financial gain or loss. The cost of manufacture was then as now in favor of the buckwheat ration and each ration made the same amounts of milk and butter.

2. The buckwheat middlings ration fed with hay and silage 162 days, as compared with the grain ration containing equal parts of corn and bran, made, at a 2 percent less cost, 3 percent more milk and 6 percent more butter. A much cheaper production of milk and butter followed the use of the buckwheat than that of the corn and bran ration. The outcome is decidedly in favor of the buckwheat ration since the total gain of $4.47, taken together with the lower cost ($0.45) gives a net gain of $4.92 and a daily net gain of 3.04 cents. This increase is about one-half in increased fertilizing ingredients and one-half in butter and skim milk.

In the last year's tests the cost of manufacture was much the same in each case. The buckwheat ration was slightly more costly but made a little more milk and butter. The outcome was on the whole quite favorable to the buckwheat ration, but not to the same extent as was the case this year. The difference is probably accounted for in a large measure by the fact that the middlings fed in the 1900 experiments were of a much better grade than those used in the experiments of 1899.

It should be remarked once again to such as may consider the use of buckwheat middlings in a dairy ration that it is probably wise not to feed them so extensively as was done in our experiments; that several of the cows did not take kindly to them, some refusing them absolutely; and that there seems reason to believe also that when fed in considerable quantities they may slightly injure the butter.

The salient points of the last table and of the discussion following the same are shown herewith. The table exhibits the days of feeding on each ration, the added cost for feed of the cottonseed-linseed or the corn and bran ration, the net gain from butter sales, the net profit when butter is considered the only asset, the value of the skim milk and of two-thirds of the manurial ingredients, the net gain from butter, skim milk and manure and the net gain from feeding one cow for one day.

RELATIVE VALUES OF THE SUNDRY RATIONS

	Buckwheat middlings ration superior to	
	Cottonseed-linseed ration	Corn and bran ration
Days of feeding	162	162
Added cost of cottonseed-linseed or corn and bran ration	$1.77	$0.45
Net gain from butter sales @ 20 cents	$0.20	$2.00
Net gain, i. e. lessened grain cost plus increase in butter	$1.97	$2.45
Value of skimmilk and of two-thirds manurial ingredients	—$0.06	$2.47
Net gain from butter, skimmilk and manure	$1.91	$4.92
Net gain from one day's feeding of one cow	1.18 cents	3.04 cents

VI. FEEDING VALUES OF MEDIUM AND OF WIDE RATIONS

Many trials of this nature have been made at this and at other stations.[1] The present test is in continuation of a trial made last year and reported at that time. The grain rations and roughages were the same in each case, hay, silage and, in alternating periods, mixed feed No. 1 and Quaker dairy feed[2].

FEEDING

Hay, silage, and 8 pounds of grain were fed. Five cows, four mature animals and one a three-year-old, were fed in these trials. Two were fresh or nearly so, two were about five months along in lactation[3] and one was farrow. One of the two well along in lactation remained farrow.

COMPARISON WITH STANDARDS[4]

Wolff.[4]—Two cows ate in excess of requirements, except for protein when on the Quaker ration; two cows, Jip and Max Belle, ate closely standard rations, except for protein when on the Quaker ration and, in period III in Jip's case; and one cow, Maizie, whose teeth were in poor shape and getting worse, was unable to eat at any time the full amount she should have had.

Wolff-Lehmann.[4]—These cows, with one exception, yielded relatively small milk flows. The Wolff-Lehmann standard takes this into account. It was not, however, built primarily for cows giving 6.50 to 7 percent of fat in their milk. Hence it follows that these five cows all ate more than standard amounts of food, most of them much more, and some very much more. Even Maizie, with her poor teeth, and, at this time, scanty milk flow, ate in two of the three periods enough protein when on the Quaker diet to meet standard requirements. This is clearly a case where judgment should have dominated—as it did—over standards.[1]

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[1] A somewhat complete reference list to these trials is given in footnote of Vt. Sta. Rpt. 12, p. 276 (1899).

[2] There were variations in both feeds one year as compared with another. The No. 1 feed contained in 8 parts by weight this year, 4 parts bran and 1 part corn, and last year 3 and 2 parts respectively. Quaker dairy feed has superceded the Quaker oat feed which was used last year. It contains about 2 per cent more protein than it did formerly.

[3] One of these, Jip, had aborted; hence her small milk flow.

[4] See footnote, page 405.

RESULTS

The following table[2] summarized from those at various points in the appendix, shows the increase or decrease—expressed as percentages, total equaling 100—of dry matter eaten, of milk, total solids and fat given, and of the same per 100 pounds of dry matter eaten, both in the total rations and in the experimental portions thereof, when a cottonseed-linseed ration (No. 1) of "medium" balance and fed in medium quantity—nutritive ratios ranging from 1:4.7 to 1:5.8 and averaging 1:5.3—replaced a Quaker dairy (oat) feed ration of "wide" balance and fed in medium quantities—nutritive ratios ranging from 1:6.6 to 1:8.7 and averaging 1:7.7—or vice-versa; hay and silage being fed as roughages throughout.

SUMMARY OF DIFFERENCE TABLES,[2] ETC. (APPENDIX VI (*b*) AND VII)

RATIONS	Total dry matter eaten	Dry matter eaten in concentrates	Quantity of milk	Total solids, per cent	Fat, per cent	Quantity of total solids	Quantity of fat	Products per 100 pounds of dry matter						Ratio of fat to solids-not-fat
								In entire ration			In experimental feed			
								Milk	Total solids	Fat	Milk	Total solids	Fat	
(*a*) Quaker dairy feed ± mixed feed 1	+ 1	+ 4	−6	0	+1	−5	−5	−8	−7	− 6	− 9	− 8	− 8	
(*b*) Mixed feed 1 ± Quaker dairy feed	0	− 2	+6	0	0	+6	+6	+5	+6	+ 6	+ 7	+ 7	+ 7	
(*c*) 342 days feeding on mixed feed 1 ± 342 days feeding on Quaker dairy feed	− 1	− 3	+6	0	0	+6	+6	+7	+8	+ 6	+ 8	+ 8	+ 8	0

CONCLUSIONS

The producing power of a unit of dry matter was 6 percent greater when the cottonseed-linseed ration was used in place of the dairy feed. The quality of the milk was unchanged by the variations in feeding. This outcome is identical with that obtained last year with rations nearly the same in character. It is, moreover, the result which may usually be expected. And, as has ordinarily been the case, the better ration proved the cheaper. It cost more to make a pound of butter on the richer ration, but it made more butter, more skim-milk and richer manure.

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[1] In this connection see Vt. Sta. Bul. 81, pp. 14–17 (1900).

[2] See footnote, page 406.

VII. THE FEEDING VALUES OF RATIONS OF APPROXIMATELY EQUAL BALANCE

The last three reports[1] contain data on this subject. A further trial made during the past winter adds to those already accumulated. It closely resembles one of the trials made last year, the same roughage and concentrates, half and half corn and bran and Quaker dairy feed, being used. Inasmuch as full discussions of the problems involved and the results obtained was made last year, the present statement will be confined solely to the outcome of this year's experiments.

The improved grade of the Quaker dairy feed[2] was overlooked in planning this trial, and exact "equal balance" was not attained. Had a little less corn meal been fed and a fraction of a pound of gluten meal been inserted in the corn and bran ration a close equibalance would have been attained. The somewhat variable character of the hay, however, was bound to introduce a disturbing element. The test, therefore, really becomes one of rations, the digestible protein content of which was fairly uniform and the digestible carbohydrates content rather unlike.

FEEDING

Hay, silage, and, in alternating periods, 8 pounds of equal parts of corn and bran or of Quaker dairy feed were fed. The latter grain ration was not well relished by some of the cows and some of it remained uneaten. This naturally affected the conduct of the test, which was, on this account, less satisfactory than the similar trial last year.

Five cows, four mature and one three years old were used. Only the latter was fresh in milk, the others being from five and one-half to eight months in lactation. Two of these, however, were farrow.

COMPARISON WITH STANDARDS[2]

Wolff.[3]—All the cows ate much more total and digestible dry matter than standard calls for, and much more digestible carbohydrates and fat, but much less digestible protein. They ate enough as a whole for much larger cows, but their ration was always far wide of standard.

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[1] Vt. Sta. Rpts. 10, pp. 162–164 (1897), 11, pp. 330–336 (1898), 12, pp. 262–269 (1899.)

[2] See footnote 2, page 427.

[3] See footnote, page 405.

Wolff-Lehmann.—The same condition of affairs—hearty eating—appears as was shown when comparison is made with the Wolff standard. Even the protein consumption was equal to or in excess of standard demands. The cows used in this test were in some cases approaching the end of lactation or were farrow. Standards are less closely applicable then than when used for cows in flush of milk.

RESULTS

The following table,[1] summarized from various points in the appendix, shows the increase or decrease—expressed as percentages, total equaling 100—in dry matter eaten, milk, total solids and fat given, and of products per 100 pounds of dry matter, both in the total and in the experimental portions of the ration when a Quaker dairy feed ration—nutritive ratios ranging from 1:7.3 to 1:8.9, and averaging 1:8.0—was fed in place of a ration of equal parts bran and corn meal—nutritive ratios ranging from 1:7.9 to 1:9.2 and averaging 1:8.6, or vice versa; hay and silage being fed as roughages throughout.

SUMMARY OF DIFFERENCE TABLES,[1] ETC. (APPENDIX VI (*b*) AND VII)

RATIONS	Total dry matter eaten	Dry matter eaten in concentrates	Quantity of milk	Total solids, per cent	Fat, per cent	Quantity of total solids	Quantity of fat	Products per 100 pounds of dry matter						Ratio of fat to solids-not-fat
								In entire ration			In experimental feed			
								Milk	Total solids	Fat	Milk	Total solids	Fat	
(*a*) Quaker dairy feed ± corn and bran	− 1	− 3	+2	0	−1	+2	+1	+3	+3	+ 2	+ 6	+ 5	+ 5	
(*b*) Corn and bran ± Quaker dairy feed	+ 2	+ 4	+2	0	0	+2	+2	−1	0	0	− 4	− 3	− 3	
(*c*) 216 days on corn and bran ± 216 days on Quaker dairy feed	+ 1	+ 4	0	0	0	0	0	−1	−2	0	− 4	− 4	− 4	0

CONCLUSIONS

1. About two percent more product resulted to the unit of dry matter when the Quaker ration was fed than when the corn and bran were used.

2. The quality of the milk was unaffected by the changes in feeding.

3. The ration which furnished somewhat the less digestible dry matter, but had a slightly narrower nutritive ratio, seems to have come out ahead. The differences, however, are not large enough to lay stress upon, and are quite within the limits of experimental error.

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[1] See footnote, page 406.

Practically the rations had closely similar values for dairy purposes. A similar conclusion was reached as a result of last year's trials.

FINANCIAL CONSIDERATIONS

The money side of the question as to the relative value of the several rations used in the trials cited under heads VI and VII in the past four pages is developed in the following table and comments. The table is of the same general character as those appearing on pages 410-413, and the descriptive and explanatory remarks preceding them apply here with equal force. It may be remarked, in addition to the data there given as to cost of the sundry grain feeds, that Quaker dairy feed cost $18.00 a ton.

COMPARATIVE VALUES OF VARIOUS RATIONS FROM THE FINANCIAL STANDPOINT

RATIONS	Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Quaker dairy feed	Milk	Butter	Money value of food	Cost of food for		Proceeds for butter at 20 cents	Fertilizing value of food eaten
										100 lbs. of milk	1 lb. butter		
	lbs.	lbs.	lbs	lbs.	lbs.	lbs.	lbs.	lbs.	$	cts.	cts.	$	$
342 DAYS ON QUAKER DAIRY FEED RATION VS. 342 DAYS ON COTTONSEED, LINSEED, CORN AND BRAN RATION (8 LBS. DAILY EACH RATION)													
Quaker dairy feed	3667	8777	...	....	....	2636	4700	324	55.23	117.5	17.0	64.80	29.19
Cottonseed, etc	3558	9110	341	1357	1023	....	4982	343	60.17	120.8	17.5	68.60	40.50
Difference in favor of cottonseed, etc							+282	+19	+4.94	+3 3	+0.5	+3.80	+11.31
Percentage differences							+ 6	+ 6	+ 9	+ 3	+ 3	+ 6	+ 39

Total value of butter, skimmilk and two-thirds of fertilizing ingredients; Quaker dairy ration, $92.33, cottonseed, etc., ration, $104.15.

Difference in favor of cottonseed, etc., ration, $11.82.

Gain ($11.82), less extra cost ($4.94), gives net gain, $6.88; daily net gain, 2.01 cents.

216 DAYS ON QUAKER DAIRY FEED RATION VS. 216 DAYS ON CORN AND BRAN RATION (8 LBS. DAILY EACH RATION)

RATIONS	Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Quaker dairy feed	Milk	Butter	Money value of food	Cost of food for 100 lbs. of milk	Cost of food for 1 lb. butter	Proceeds for butter at 20 cents	Fertilizing value of food eaten
Quaker dairy feed	2505	6841	...	....	....	1573	3381	219	36.95	109.3	16.9	43.80	19.86
Corn and bran	2506	6908	856	858	....	....	3377	220	38.32	113.5	17.4	44.00	21.59
Difference in favor of corn and bran							− 4	+ 1	+1.37	+4.2	+0.5	+0.20	+ 1.73
Percentage differences							0	0	+ 4	+ 4	+ 3	0	+ 9

Total value of butter, skimmilk and two-thirds of fertilizing ingredients; Quaker dairy ration, $62.84, corn and bran ration, $64.20.

Difference in favor of corn and bran ration, $1.36.

Gain ($1.36), less extra cost ($1.37), gives net loss, $0.01; daily net gain or loss, 0.

1. The cottonseed-linseed ration fed with hay and silage 342 days cost 9 percent more than did the Quaker dairy feed ration fed the same length of time. It made 6 percent more milk and butter. Owing to the higher prices paid for the concentrates in the former ration it cost 3 percent more to make milk and butter therefrom than it did from the Quaker dairy ration. Inasmuch, however, as the production and the income from butter were 6 per cent greater, and inasmuch as there was 39 per cent increase in the fertilizing ingredients in the cottonseed-linseed ration as compared with the Quaker dairy feed ration, it follows that the more costly ration was in reality the cheaper. Its use was followed by the production of $3.80 worth more butter and about $2.50 worth more skimmilk and additional fertilizing ingredients "valuing" $11.31. The total gain from butter, skimmilk and two-thirds of the fertilizing ingredients is $11.22, which, less the extra cost, $4.94, gives a net gain of $6.88. The use of the cottonseed-linseed ration in the place of the Quaker dairy feed ration entailed a daily net gain of 2.01 cents for each cow.

In the experiments reported last year the cottonseed-linseed ration costs 7 percent more than did the Quaker feed and made 6 percent more product. The costs of manufacture were identical. The general outcome was much the same as the present year, The daily net gain was 2.64 cents. The material fed last year was "Quaker oat feed." The material fed this year was "Quaker dairy feed." The latter has superseded the former in Vermont markets and is of a higher grade, as judged by analysis, than was its predecessor. This probably accounts in some degree at least for the better results obtained this year.

2. The grain ration made up of equal parts of corn and bran fed with hay and silage for 216 days cost 4 percent more than did the Quaker dairy feed ration and made the same amounts of milk and of butter. The fertilizing ingredients in the former ration valued $1.73 higher than in the latter ration. Using the assumptions concerning skimmilk and the manurial values hitherto explained, the gain in favor of the corn and bran ration—located entirely in the fertilizing ingredients—is $1.36. Its extra cost was $1.37; hence a net loss of one cent followed its use. It may be said therefore that one ration was practically as good as the other.

In the experiments made last year each ration made equal amounts of milk and butter at essentially equal cost. The balance was in favor of the corn and bran because of its greater plant food content. The main reason for the slightly less favorable outcome of this year from the financial standpoint is due to the fact that bran cost $15 one year and $18 the next. From the standpoint of production the results have been practically the same each year and each ration has proved to be of essentially equal value for milk and butter making.

The salient points of the table on the last page and of the discussion following are given herewith. The table shows the days of feeding on each ration, the additional cost of the cottonseed-linseed and corn and bran rations, the net gains from butter sales, the net loss when these alone are considered as an asset, the value of the skimmilk and of two-thirds of the manurial ingredients, the net gain from butter, skimmilk and manure and the net gain from feeding one cow for one day.

RELATIVE VALUES OF THE SUNDRY RATIONS

	Cottonseed-linseed ration	Corn and bran ration
	Superior to Quaker dairy feed ration	
Days of feeding each ration	342	216
Cost of cottonseed-linseed or of corn and bran over Quaker dairy feed	$4.94	$1.37
Net gain from butter sales @ 20 cents	$3.80	$0.20
Net loss, i. e. added cost grain less value increase of butter	$1.14	$1.17
Value of skimmilk and of two-thirds manurial ingredients	$8.02	$1.16
Net gain from butter, skimmilk and manure	$6.88	—$0.01
Net gain from one day's feeding of one cow	2.01 cents	0

The results of two years tests serve but to confirm the writer in his judgment that the class of goods, of which the Quaker dairy feed is a high grade type, at the prices which commonly rule for grain feeds in New England, is more expensive as a feed for dairy cows and less well adapted to that purpose than other admixtures of grains and byproducts which may be readily made by any dairyman who will put some thought and study into the matter.

VIII. THE GROOMING OF COWS

Few dairymen pay as much attention as is desirable to the cleanliness and physical comfort of their cows. It has been clearly demonstrated that a higher grade of product follows the adoption of cleanly methods. If it might also be shown that more or richer milk was the reward of him who observed sanitary rules in the management of his barn, an additional point in favor of the gospel of cleanliness would be gained.

The results of a trial of the effects of grooming cows upon the milk flow were given in the last report[1]. Further work along the same line has been carried on with results as shown herewith.

FEEDING

Three cows were fed hay, silage and mixed feed No. 1. Rations were fairly uniform throughout the trial,[2] but in alternating periods, the animals were carded or were left ungroomed. Even when left uncarded, however, the cows were not as dirty as is too commonly the case among careless dairymen.

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[1] Vt. Sta, Rpt. 12, pp. 285-286 (1899).

[2] Bettie and Salida were, through error, irregularly fed. Each received more silage in two periods than in the others. Bettie ate 8 percent more total and digestible dry matter in periods 4 and 5 and Salida 8 percent more in periods 5 and 6 than in the preceding and succeeding periods. No more protein was eaten, however, at one time than another. Nutritive rations were naturally somewhat variable. It is not thought, however, that these errors markedly affected the general result. At any rate, if generalizations are attempted from the record of the one cow which was uniformly fed they would be the same as those advanced as a result of the study of all three records.

COMPARISON WITH STANDARDS[1]

Wolff.[1]—The two heavier cows ate somewhat more total and digestible dry matter and carbohydrates, but only a little more protein than the standard requirements. The smaller cow—Salida—ate as much as the larger ones, and in excess over requirements of all nutrients. Nutritive ratios were on the whole closely standard.

Wolff-Lehmann.[1]—All nutrients were eaten in amounts equal to and in some cases greater than the standard requires.

RESULTS

The following table[2] summarized from those at various points in the appendix shows the increase or decrease—expressed as percentages, total equaling 100—in dry matter eaten, milk, total solids, and fat given, and of products per 100 pounds of dry matter both in the total ration and in the grain ration when the cows were groomed as compared with the times when they were left uncarded; hay and silages as roughages and mixed feed No. 1 as concentrate being fed throughout, nutritive ratios ranging from 1:5.0 to 1:6.0 and averaging 1:5.5.

SUMMARY OF DIFFERENCE TABLES,[2] ETC. (APPENDIX VI (*b*) AND VII)

RATIONS	Dry matter	Dry matter in grain feed	Quantity of milk	Total solids, per cent	Fat, per cent	Quantity of total solids	Quantity of fat	Products per 100 pounds of dry matter						Ratio of fat to solids-not-fat
								In entire ration			In grain ration			
								Milk	Total solids	Fat	Milk	Total solids	Fat	
(*a*) Groomed ± not groomed	+ 1	− 1	−6	−1	−1	−6	−5	−6	−7	− 8	− 4	− 5	− 4	
(*b*) Not groomed ± groomed	+ 3	+ 2	+3	+1	+1	+4	+4	0	+1	+ 1	+ 1	+ 2	+ 2	
(*c*) 126 days not groomed ± 126 days groomed	+ 1	+ 2	+4	+1	+1	+5	+5	+3	+5	+ 5	+ 2	+ 3	+ 3	0

CONCLUSIONS

1. A unit of total and of digestible dry matter yielded 4 per cent less when the cows were groomed than when they were left uncarded.

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[1] See footnote, page 405.

[2] See footnote, page 406.

2. There was practically no difference in the quality of the milk given under these different conditions. Such slight change as was observed was in favor of the ungroomed condition.

In last year's tests with five cows neither quantity nor quality was affected materially. Such slight quality change as was observed favored grooming.

Backhaus[1] reports from 2.5 to 8 per cent increase in the milk yield as a result of grooming. Our results are less favorable. They do not offer any hope that increased yield will result from grooming, but indeed, if anything, that a lessened flow may result. It is not thought, however, that this latter outcome is certain enough to lay stress upon. The only outcome of these two trials upon which emphasis can be safely laid is that the dairyman can hardly expect to tickle his cows into giving more milk. Grooming should lessen the bacterial content of a cow's milk but is not likely to add to its amount or to its fat content.

IX. WATERING COWS AT WILL AND AT INTERVALS

It is ordinary Vermont farm practice to water cows in the winter twice a day. There are in use, however, devices which enable a cow to drink whenever she pleases, and as much as she wishes to. Does the use of these devices increase the milk yield and the butter product, provided an apparent sufficiency is drunk in each case?

The results of a trial of this matter were given in the last report.[2] Further work along the same line has been done with results as shown herewith.

FEEDING

Four mature cows were fed hay, silage and mixed feed No. 1 for 3 periods, being treated similarly throughout save that, in alternating periods, they drank water whenever they wished, or only at intervals. In the former case the water was kept in buckets in the mangers and supplied as drunk; in the latter case the cows were watered twice daily, drinking as much as they wished each time. The amount of water drunk was weighed in each case.

COMPARISON WITH STANDARDS[3]

Wolff.[3]—All four cows ate more total and digestible dry matter and of all the nutrients than the standard requires. They ate feed equivalent to the standard wants of cows 150 pounds of greater weight, but, notwithstanding, did not lay on flesh.

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[1] Jour. f. Landw 41., p 332 (1893).

[2] Vt. Sta. Rpt. 12, pp. 286-287 (1899).

[3] See footnote, page 405.

Wolff-Lehmann[1].—Less total dry matter and less protein were eaten than the standards demanded; but an entire sufficiency of digestible dry matter carbohydrates were consumed.

RESULTS

The following table[2] summarized from those at various points in the appendix shows the increase or decrease—expressed as percentages, total equaling 100—in dry matter eaten, in milk, total solids and fat given and of products per 100 pounds of dry matter eaten, both in the total ration and in the grain ration when watering at will was practiced instead of watering at stated intervals or vice versa; hay and silage as roughages and mixed feed No. 1, as concentrate being fed throughout, nutritive ratios ranging from 1:4.9 to 1:5.9 and averaging 1:5.4.

SUMMARY OF DIFFERENCE TABLES [2] ETC. (APPENDIX VI (*b*) AND VII)

WATERING	Dry matter	Dry matter in grain rations	Quantity of milk	Total solids, per cent	Fat, per cent	Quantity of total solids	Quantity of fat	Products per 100 pounds of dry matter						Ratio of fat to solids-not-fat
								In entire ration			In grain ration			
								Milk	Total solids	Fat	Milk	Total solids	Fat	
(*a*) Water at will ± water at intervals	+ 5	+ 3	+1	0	0	+1	+1	−4	−4	− 4	− 2	− 2	− 2	
(*b*) Water at intervals ± water at will	+ 3	+ 2	+1	+2	+4	+2	+4	−3	−1	+ 1	− 1	0	+ 2	
(*c*) 90 days' feeding, water being drunk at intervals, ± 90 days' feeding, water being drunk at will	0	0	0	+1	+2	+1	+2	0	+1	+ 3	0	+ 1	+ 2	−2

CONCLUSIONS

The cows when drinking water whenever they wished to and in such quantities as they desired made no more and no better milk than when they drank but twice daily.

The water drunk was weighed throughout the feeding trials. The consumption of water varied somewhat as the amounts of silage eaten differed. Analyses of the feeds for water together with their weights show the total water consumption of each cow. Two animals used almost identical amounts whether drinking twice or oftener; one used about 3 percent more when it could drink as it pleased, the other 6 percent less under those conditions. Of the two cows which used the same water either way they got it, one made 1 percent more milk and milk products when drinking at will, but 3 percent less in proportion to the dry matter eaten; the other made 2 to 3 percent more milk and its products when drinking twice daily, but 3 percent less in proportion to the dry matter eaten. The cow consuming 3 percent more water when getting it at intervals made from 4 to 6 percent more milk, etc., and 2 percent more to the unit of dry matter eaten. The cow which got 6 percent more when drinking at will made from 1 to 2 percent more milk but less to the unit of dry matter. The outcome whether figured according to the food or the drink is the same. No advantage, so far as the quantity or the quality of the milk is concerned, resulted from allowing the cows to have access to drinking water at all times as compared with drinking twice daily. Whether a similar outcome would have been attained had the cows received a dry ration instead of a succulent one cannot be told.

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[1] See footnote, page 405.

[2] See footnote, page 406.

The results of both years' trials are practically identical. They are quite contrary to those obtained by Backhaus[1] and cited in the last report. He obtained an increase of a pound daily in milk yield without any diminution in total solid and fat contents following a change from watering twice daily to a constant water supply. It is the writer's judgment however that convenience rather than more milk is the main argument in favor of watering in the barn.

X. WARMING WATER FOR COWS

The warming of water for cows has been advocated more or less for a long time. One may go back thirty years or more in the files of agricultural papers and find the matter discussed with arguments pro and con. There have not been, however, any large number of careful tests of the proposition, and it seemed worth while to attempt such a trial during the past winter.

FEEDING

Six cows were used in these trials. All were mature animals. Three were from 3 to 4 months in lactation, one 6 months, and two quite far along in lactation. All were giving from good to fair amounts of milk at the outset of the tests. They were fed uniform rations of hay, silage and mixed feed No. 1, and in alternating periods were given water at from 42 to 48 and at 70° F. The water was drunk twice daily and the amounts weighed.

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[1] Milk Zeit., 21, pp. 509-512 (1892); Ber. Landw. Inst. Univ. Kœnigsberg, 2, p. 34 (1897).

COMPARISON WITH STANDARDS [1]

Wolff.[1]—All the cows ate dry matter and nutrients equal to or in excess of requirements. They ate as a rule enough for cows of 50 to 100 pounds greater weight.

Wolff-Lehmann.[1]—All the cows ate nutrients in excess of standard, but some, less dry matter than called for. The eating was considerably in excess of standard needs, since most of the cows used in this test were well along in lactation.

RESULTS

The following table[2] summarized from various points in the appendix shows the increase or decrease—expressed as percentages, total equaling 100—in dry matter eaten, milk, total solids, and fat given, and of products per 100 pounds of dry matter, both in the total and the grain rations, when water was drunk warmed or cold; hay, silage and mixed feed No. 1 being fed throughout, nutritive ratios ranging from 1:4.8 to 1:6.1 and averaging 1:5.6.

SUMMARY OF DIFFERENCE TABLES,[2] ETC. (APPENDIX VI (*b*) AND VII)

WATERING	Total dry matter eaten	Dry matter eaten in concentrates	Quantity of milk	Total solids, per cent	Fat, per cent	Quantity of total solids	Quantity of fat	Products per 100 pounds of dry matter						Ratio of fat to solids not-fat
								In entire ration			In grain ration			
								Milk	Total solids	Fat	Milk	Total solids	Fat	
Cold water ± warmed water..	+1	0	+3	0	0	+3	+3	+2	+2	+2	+3	+3	+3	
Warmed water ± cold water..	0	0	−1	+1	0	−1	−1	−1	0	0	−2	−1	−1	
360 days feeding when cold water was drunk ± 360 days feeding when warmed water was drunk	0	0	+2	0	0	+2	+2	+2	+1	+4	+2	+2	+2	−1

CONCLUSIONS

1. Two percent more milk, total solids and fat, were made when cold water was drunk than when it was warmed. This is too small a difference to lay stress upon.
2. The quality of the milk was unaffected.
3. Warming water to 70° F. was of no avail whatever in bettering the milk yield.

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[1] See footnote, page 405.

[2] See footnote, page 406.

A study of the amounts of water drunk and of that consumed is of interest. Four of the six cows drank much more water when it was warmed than when it was cold, one a little more and one about the same. The cold water was drunk more freely in November and in May than in the intervening months. This is probably due to its higher temperature—49 and 48° instead of 42° F.—and because of the warmer barn and temperature. At all other times it was drunk much less freely than was the warmed water. If these be omitted every cow is found to have drunk the warm water more freely than the cold in amounts averaging from 8 to 23 percent. This increase in water consumption, however, as has been seen, entailed no increase in the milk flow or decrease in its quality. In other words, the cow did not water her milk by increased drinking. The individual cows made sometimes a little more and sometimes a little less milk when drinking the large amounts of water. The cows ate no more when drinking cold water than when it was warmed, nor did live weights favor either method of watering.

Several trials of warming water for cows were made some ten years ago by sundry stations.[1] The Wisconsin tests were extensive, the others less so.

Increase in consumption of water when warmed was universally observed. From no increase up to 6 percent more milk was made when the water was warmed. In the Wisconsin tests it took a little more food to make a pound of milk and butter when the water was cold. Also the more water was drunk the more milk was made, regardless of the temperature.

Their results showed a slight financial advantage, amounting to about 25 cents to each cow for a winter, from giving water at 70° instead of at 32° F. It is generally practicable to give water at 40° throughout the winter. Whether even this little gain would follow in this case is doubtful.

It should be remembered, of course, that both the Wisconsin and the Vermont tests were made with cows which were well stabled in barns with average winter temperatures of 45° and 50°. Cows housed in cold barns may profit more by water warming. The matter therefore practically reduces itself to a consideration of the cheapest source of cow warmth—corn meal fed a cow, cord-wood burned in a water heater, or clapboards on a barn.

XI. SUMMARY

The details given in the foregoing 48 pages may be summarized under their respective reference numbers and headings as follows :

1. The nature of the problems studied.—Forty-eight cows were used in the feeding trials, which lasted 28 weeks and were meant to determine as far as it is possible for single trials to do :

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[1] Mich. Sta. Rpt. 1, pp. 139-144 (1888) ; Minn. Sta. (no. vol.) Rpt. pp. 119-121 (1888); Ind. Bul. 24, pp. 6-9, 15-16 (1889) ; New York (State) Sta. Rpt. 8, pp. 290-294 (1889) ; Wis. Sta. Bul. 21 (1889) ; Rpts. 6, pp. 146-188 (1889), 7, pp. 163-182 (1890)

(*a*) The effect on the quantity and quality of milk and on the economy of production, of low, medium and heavy grain feeding ; also the limit of profit in the addition of grain to a ration,—pages 402–417.

(*b*) The effect on the quantity and quality of milk of the addition to a ration, already fairly well adapted to milk making, of a considerable proportion of a single nutrient, either protein, carbohydrates or fat,—pages 417-420.

(*c*) The feeding value of buckwheat middlings compared with a mixture of corn, bran, cottonseed and linseed meals, considerably less rich in protein and fat than the buckwheat byproduct,—pages 421–427.

(*d*) The feeding value of buckwheat middlings compared with a half and half corn and bran mixture,—pages 421–427.

(*e*) The variation in production following the use of two rations affording food supplies essentially equal in total amount but unequal in the amounts of the various nutrients; medium and wide rations,—pages 427-429.

(*f*) The variation in production following the use of dissimilar rations each containing essentially the same amounts of the various nutrients,—pages 429–433.

(*g*) The effect on production of grooming cows,—pages 433–435.

(*h*) The effect on production of allowing cows to drink at will instead of at stated intervals,—pages 435–437.

(*i*) The effect on production of warming water for cows,—pages 437–439.

2. *Methods, details, etc.*—The feeding periods were four weeks long and many different rations were used. Hay and silage were the only roughages used and were fed to all the cows. Fifty-three cows were started in the experiments and the records of 48 were deemed safe to use. Errors in feeding, sickness, bovine idiosyncracies, etc., render untrustworthy the records of five cows and these are not considered. Full records were made, including weights of cows, fodders and feeds, milk, etc., barn temperatures were taken and constant analytical check was kept upon every phase of the work throughout the entire 28 weeks,—pages 393–401, also appendix to this report.

3. *How much grain may be fed with profit to dairy cows?*—Four, eight and twelve pounds of three different grain rations were fed at different times with hay and silage to 11 cows, each animal being kept throughout the experiment upon the same grain ration, so far as character is concerned, but a different one as regards its amount. The outcome was essentially as follows :

Quantity.—The more grain, the more milk, total solids and fat.

Quality.—Only slight changes were observed as a result of variation in amounts of grain fed. Such alterations as occurred were in the general direction of better milk on medium than on either low or high feeding.

Economy of production.—A pound of dry matter produced more on the low than on either the medium or high grain feeding. There was but little difference in this respect between the medium and the high ration.

Live weight.—Increased feeding usually affected the milk flow only in the first few months of lactation, but from the fourth month on there seemed to be a greater tendency to affect live weight than to alter the milk flow.

Financial outcome.—In these trials an increase of grain from four pounds to eight or to twelve pounds seldom yielded enough more butter to pay the cost of the extra grain. In practically every case, however, there was enough more skimmilk and enough better manure made to more than offset the extra expense for grain. In almost all cases the cows received, even when on the low grain ration of four pounds, a sufficient amount of dry matter from the roughages and from these four pounds to meet the requirements of either the Wolff or the Wolff-Lehmann feeding standards. It might be argued therefore that the addition of digestible protein and other digestible ingredients when the grain ration was enlarged to 8 or to 12 pounds was not profitable; and that, viewing the matter from the standpoint of immediate profit only, the cows, despite the dictums of those who have laid down standard rations, were able to do as well on the lower as on the better ration. It may fairly be questioned, however, whether the byproducts ought not to be reckoned upon. When they are considered the profit is each time in favor of the 8 pound ration as compared with the 4 pound and generally in favor of the 12 pound as compared with the 8 pound ration. It should be noted, moreover, that there is a greater likelihood that a cow will keep up her milk flow on a ration which is fairly liberal then on one which is stinted; and that there is a greater probability that she will maintain her live weight and vigor of constitution on a medium ration than on a poor one. As to the advisability of the 12 pound or heavy ration it may be questioned whether so large a proportion of concentrates is desirable, viewed from the standpoint of the health of the animal. The wisdom of such feeding will depend upon a multitude of considerations. The outcome of these trials is in many ways parallel to that of similar experiments lately reported by the Wisconsin station,—pages 402-417.

4. *The addition to the ration of excessive amounts of single nutrients.*—*Protein.*—The addition of about one-fifth more digestible protein to a ration already containing amounts of this nutrient greater than standard requirements was practically without effect as a milk stimulant.

Carbohydrates.—The addition of about one-fifth more digestible carbohydrates to a ration containing amounts of these nutrients equal to or in excess of standard requirements had little or no effect upon either the quantity or quality of the milk flow.

Fat.—The addition of a solid fat to a ration already containing digestible ether extract in excess of standard requirements increased its digestible fat content about one-half. It had a slight effect upon the quantity and a pronounced effect upon the quality of the milk flow. The total solid percentage was increased 2 percent (0.24 percent) and the fat 7 percent (0.36 percent). The increase appears to have been a permanent one,—pages 417-420.

5. *The feeding value of buckwheat middlings.*—*Quantity of milk.*—Buckwheat middlings and the cottonseed, linseed, corn and bran mixture (No. 1) were of about equal value as producers of milk, total solids and fat. Buckwheat middlings made from 8 to 11 percent more milk, solids and fat than did the mixture of half corn and half bran.

Quality of milk.—Whenever buckwheat middlings were fed the quality of the milk was improved nearly 0.20 percent. This disproportionate increase in the fat content of the milk was observed in last year's trials, and is plainly seen this year. It seems quite clear, therefore, that buckwheat middlings fed in considerable quantities increased slightly the fat percentage of milk.

Financial considerations.—Buckwheat middlings made cheaper milk and cheaper butter than did the cottonseed-linseed (No. 1) ration. It made a decidedly cheaper milk and butter than did the corn and bran ration. It should be remarked, however, that the character of the butter seemed somewhat impaired when buckwheat middlings was fed in excessive quantities; and it should be remembered that buckwheat middlings are highly variable according as the method of manufacture admits or excludes more or less of the hulls,—pages 421-427.

6. *The feeding values of medium and wide rations.*—The medium ration produced 6 percent more milk, total solids and fat than did the wide ration. The quality of the milk remained unchanged,—pages 427-429.

7. *The relative feeding values of rations of equal balance.*—But 2 percent more product was yielded to the unit of dry matter on one ration than was obtained from the other. The quality of milk remained unchanged,—pages 429-433.

Financial considerations.—The cottonseed, linseed, corn and bran (No. 1) ration proved superior to the Quaker dairy feed ration, in that it made enough more butter and skimmilk and enough better manure to more than offset its increased cost. Viewed from the standpoint of butter production only, however, disregarding the byproducts, and the better manure, the advantage was on the side of the Quaker dairy feed.

The corn and bran and Quaker dairy feed made equal quantities of milk and of butter. If the extra manurial value of the corn and bran ration is reckoned as an offset of its extra cost the outcome was exactly even. If this is not taken into account the dairy feed proved preferable,—pages 431-433.

8. *The grooming of cows.*—In this year's trials there was 4 percent less milk yielded when the cows were groomed than was given when they were left uncarded. The quality of the milk remained unaltered. The grooming of cows should tend to better the keeping quality of the milk and the grade of butter, but it is not probable that it will add to the milk flow or to its fat content,—pages 433-435.

9. *Watering at will and at intervals.*—No more and no better milk was made when the cows drank at will than when they drank twice daily,—pages 435-437.

10. *Warming water for cows.*—Warming water from 45° to 70° F. did not avail to improve either the quantity or the quality of the milk yield with cows stabled in barns the average winter temperature of which was 45 to 50° F.,—pages 437-439.

THE EFFECT OF FEED ON THE QUALITY OF BUTTER

Further study has been given during the past year in continuation of that hitherto made and reported[1] on the effect of sundry concentrates and of modifications in feeding rations upon the quality of butter. One hundred thirty-four separate churnings were made, and as many samples of skimmilk, buttermilk and butter were taken and analyzed. The butter samples were composited making 47 samples for analysis. The several butters were also critically examined by the station dairyman as to their quality. Tests were made in connection with the feeding trials reported in the preceding pages, and lasted from April 9 to May 15, 1900.

The milk of six different lots of cows was separately handled throughout the operation. The scheme is shown in the following table. Hay and silage were fed as roughages in all cases.

Lot number	Number of cows	April 9-27	April 27-May 15	Lot number	Number of cows	April 9-27	April 27-May 15
		Nature of rations used				Nature of rations used	
I	5	Buckwheat middlings	....	IV	3	Sugar and No. 1	No. 1
II	1	Buckwheat middlings	No. 1[2]	V	3	Palm oil and No. 1	No. 1
III	3	Atlantic gluten flour and No. 1	No. 1	VI	3	No. 1 (8 lbs. per head daily)	No. 1 (12 lbs. per head daily)

[1] Vt. Sta. Rpts., 10, pp. 175-181 (1896), 11, pp. 347-350 (1898) 12, pp. 296-298 (1899)

[2] Wheat bran 8, corn meal 2, cottonseed meal 3, linseed meal 3 parts by weight.

EFFECT ON THE BUTTER

The following statement shows the results of analyses of the butters made on the sundry rations :

Lot number	Character of feed	Number of composite samples analyzed	Volatile acids (C. C. $\frac{N}{10}$ alkali)	Iodin number	Melting point (°C)
I	Buckwheat middlings	7	29.3	25.1	35.1
II	Buckwheat middlings	4	28.7	29.5	33.9
	No. 1	4	27.9	29.1	34.3
III	Atlantic gluten flour and No. 1	4	28.0	28.2	34.5
	No. 1	4	28.5	27.8	33.9
IV	Sugar and No. 1	4	29.3	25.9	34.4
	No. 1	4	28.3	27.5	34.0
V	Palm oil and No. 1	4	28.8	25.9	35.8
	No. 1	4	29.2	27.0	34.1
VI	No. 1 8 lbs. a head daily	4	28.5	29.0	34.4
	No. 1 12 lbs. a head daily	4	28.3	28.7	34.0

Buckwheat middlings.—The five cows of lot No. I were fed buckwheat middlings with hay and silage throughout the five weeks. The amount of the middlings fed averaged about six and one-half pounds daily. The volatile acid figures are as high as the highest and well above the average of those obtained on the other rations ; the iodin number is much lower than the lowest and far lower than the average figures obtained on the other rations ; and, with the exception of the case when palm oil was fed, the melting point of the butter fat was well above all others. The single cow of lot II which was changed from buckwheat middlings to mixed feed No. I gave, when on the former ration, butter with a higher volatile acid content, but disagreeing with her five mates, a higher iodin number and a lower melting point. Last year's observation[1] on a single sample was in exact accordance with the results obtained on lot I this year. It would seem therefore that buckwheat middlings tend to make a somewhat firmer butter than does the cottonseed-linseed ration,—and, including last year's data, than does corn and bran, Buffalo gluten feed and Quaker oat feed,—one carrying a higher volatile acid content and a lower iodin number, and presumedly relatively more stearin and less olein.

Added protein.—The gluten flour was used as has hitherto been pointed out,[2] to add considerable amounts of digestible protein to the ration. The results upon the quality of the butter as judged by analysis are indeterminate.

Added carbohydrates.—Sugar was used to add[2] digestible carbohydrates to the ration. The volatile acid content of the butter was increased and the iodin number decreased quite decidedly in each case. The melting point remained essentially unchanged. These results were quite as marked with each individual sample as with the average.

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[1] Loc cit. [2] Page 417.

Added fat.—Palm oil was used to increase the fat consumption.[1] The volatile acids content remained unaltered, the iodin number dropped somewhat and, as was to be expected, the melting points of the butter fat soared upwards nearly 2°C. Experiments hitherto reported here[2] and elsewhere[3] have indicated that the oils containing relatively large percentages of the harder fats have this general effect upon the firmness of the butter.

Varied amounts of grain feed.—No effects were traceable in the analytical data which were to be ascribed to increase in the amount of grain fed.

EFFECT ON CREAMING, CHURNING, ETC.

Careful record of the details of these operations including the analyses of the byproducts was kept throughout the work. Study of the data reveals so many inequalities that but few deductions are deemed safe. Skimming—with one exception, possibly an error in the sample,—was uniformly good, regardless of the ration fed, and added proof, if such were needed, that a good centrifugal separator, properly run, will successfully skim any sweet and normal milk. The buttermilk analyses are uneven, yet there seems to be a decided tendency towards thinner buttermilk on those churnings which made butter of the higher melting points and vice versa.

EFFECT ON THE QUALITY OF THE BUTTER.

The station dairyman reports that none of the butters were inferior, but that the grain was more or less affected in a few cases, notably when the palm oil and buckwheat middlings were fed. Unfortunately he lost his records which makes his observations of less value than usual.

RECORDS OF THE STATION HERD FOR 1898-1899 AND FOR 1899-1900

A record has been kept of the dairy performances of each cow in the station herd from its establishment in 1889. For some years these records have been tabulated and commented upon in the station publications.[4] This work will be continued and it is hoped that in the near future the vast amount of data thus collected may be digested and matter of considerable value obtained. The records for 1892 and 1893 cover production only. Those for the past six years have also shown important data connected with the economy of production. The records shown on the next few pages, therefore, include for each cow each year, not only the production of milk, total solids, fat and butter, but also the cost of the food eaten to the 100 pounds of milk and to the pound of fat and butter, the cost of the total food eaten, of the purchased grain, the net proceeds from butter sales —at the average price actually received during the year for butter—and the value of the fertilizing ingredients in the fodders and feed eaten.

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[1] Page 417.

[2] Loc. cit.

[3] N. H. Sta. Bul. 16 (1892); Me. Sta. Rpt. 14, pp 97-113 (1898)

[4] Vt. Sta. Bul. 33 (1893); Rpts. 6, pp. 119-121 (1892); 7, pp. 82-83, (1893); 9, pp. 187-192 (1895); 10, pp. 181-188 (1897); 11, pp. 355-365 (1898); 12, pp 299-307 (1899).

The average production of milk and of butter for the entire herd in the successive years has been satisfactory and quite uniform. The butter productions have been as follows: 1892, 335 pounds; 1893, 330 pounds; 1894, no record; 1895, 325 pounds; 1896, 324 pounds; 1897, 338 pounds; 1898, 313 pounds; 1899, 320 pounds; 1900, 357 pounds. The herd of 1892-93 contained about twenty cows and was slaughtered early in 1894 because of tuberculosis. The animals included in the present herd were bought at varioustimes, from 1894 to 1900. There were 62 cows in the herd within the limits of the first, and 59 cows in the second record year[1] but only 47 and 45 were members throughout the two years. Some of the dozen or more cows not figuring in the main tabulations were heifers with their first calves. Some were sold for beef, some were purchased during the year and a few died. The records of the cows which did not finish their record year have been kept as carefully as have those of the animals which completed the year. These broken records have not the value that pertains to complete data, yet, inasmuch as several of these cows have figured in past records and many of them will figure in future ones, it is thought best to publish the figures. They follow the main tabulations on pages 452-453. The 47 cows at the farm throughout the earlier year included nine two-year-olds. The 38 older cows averaged 339 pounds of butter. The animals whose names are italicized in the tables are registered Ayrshires, those in black face registered Jerseys. All others are high grade Jerseys. Many of the animals have higher records in past years than those given in the present tabulations.

The remarks on this and the succeeding page are explanatory of the record tables of the two years on pages 448-453.

"*Pounds of milk*" are obtained by weighing each milking of each cow throughout the year.

"*Percent of fat*" is obtained by averaging by cross-division. Composite samples—eight milkings each—are taken of the milk of each cow bi-monthly throughout the year and constantly while on feeding experiment.

"*Pounds of butter*" are obtained by adding *one-sixth* to the pounds of fat, this being the factor adopted by the Association of American Agricultural Colleges and Experiment Stations and based upon the world's fair dairy tests. This is equivalent to a "surplus" of 16.7 percent. The conditions of our work (frequent sampling, varying methods of handling, frequent handling of relatively small quantities, etc.) are such that is is doubtful whether our average "surplus" is as high as 16.7 percent. Much of our product is sold as cream, a little as milk, and large amounts are taken as samples; hence our exact make *all as butter* cannot be stated. Conservative estimates of the butter values of these last three items together with butter sales, compared with calculations using the one-sixth factor, have in years past agreed within a narrow margin and show a surplus of 12 to 14 percent. It would be unfair, however, to charge against the cows the relatively small losses of butter which are to a considerable extent caused by the peculiar nature of our work and which would not pertain to ordinary dairy management.

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[1] Nov. 1 to Oct. 31 constitutes a record year.

"*Cost of food*" is reckoned from prices paid for grain—corn-meal $17-$18, bran $15-$18, cottonseed meal, $25-$26, linseed meal, $25.50-$26.50, Buffalo gluten feed, $19-$22.25, buckwheat middlings, $18-$21.20, Quaker oat or dairy feed, $16.50-$18—hay, $9-$10, silage, soiling crops, $3; pasturage for the season, $5 per animal.[1]

The average cost of food for 100 pounds of milk and for a pound of butter as stated in the table is obtained by dividing the total by 47 or 45, thus giving each cow the same value in the average, be she good, bad or indifferent. *As a herd* the average cost of food for 100 pounds of *herd* milk were 82.6 (1899) and 88.3 (1900) cents and for a pound of butter 14.1 (1899) and 14.7 (1900) cents.

The figures showing "cost of 100 pounds of milk" and "cost of one pound of butter," include only the cost of food as laid down in barn ready for feeding. They do not include cost of feeding, caring for cows, making and marketing butter, depreciation of plant, interest on investment, etc.

It should be noted, however:

1. That "roughages" are rated as figures sufficiently liberal to more than cover the cost of raising and harvesting in average seasons.
2. That the fertilizing ingredients in the food fed at the barn are worth nearly half of the rated cost if reckoned at market prices for the same plant food of nearly if not quite the same availability in the form of commercial fertilizers. There are also considerable amounts of plant food in the pasture grass not included in the schedule.
3. That the fertilizing ingredients in the grain purchased were worth, when similarly rated, about three-fifths of its market price.
4. That a ton of butter removes but $0.41 worth of plant food.
5. That the increase of the herd and the sales of calves and fat cows are further items not considered above.
6. That the skim-milk and buttermilk from the 45 cows, at 20 cents per hundred (which was its feeding value found in the pig feeding experiments of 1895 and 1896, the last made at the station, with dressed pork at 5 cents), was worth for the two years in the vicinity of $900.00.

Herd records of this character have now been kept for six years. A combined statement is of interest and is shown on pages 454 and 455.

RECORD OF THE HERD OF THE VERMONT AGRICULTURAL EXPERIMENT STATION FOR THE YEAR FROM NOV. 1, 1898, TO OCT. 31, 1899

Cow	Approximate weight	Age November 1, 1898	Calved in 1898	Calved in 1899	Days in milk	Milk	Total solids	Fat	Total solids	Fat	Butter
						lbs	%	%	lbs	lbs	lbs
Acme 5th, 10342 A. R	950	9	Dec. 25	Dec. 3	309	6775	11.94	3.81	808.9	258.4	301.5
Adah	700	2	Nov. 22	Apl. 1, '00	341	3422	14.40	5.11	492.6	174.7	203.8
Atalanta 10777, A. R	1000	9	Nov. 16	Jul. 20, '00	310	9740	12.38	3.78	1205 4	368 0	429.4
Bettie	1030	10	Feb. 6	March 1	341	5894	13.69	4.67	807.1	275.1	321.0
Bonny Belle	850	2	Dec. 7	Killed	332	4241	14.43	4.99	611.9	211.6	246.9
Ceres	880	8	*Sept. 18	Aug. 2	262	4487	15.01	5.73	673.6	256.9	299.7
Clare	980	11	July '97	Jan. 22	287	7462	13.57	4.71	1012 6	351.4	410.0
Clover	1000	11	Jul 25, '97	March 1	242	5167	14.57	5.35	752 7	276.5	322.6
Dandelion	850	9	Feb. 28, '99	Killed	302	5110	14.02	5.14	716.3	262.5	306.3
Dime, 15732 A. R	850	2	Jan. 8, '99	Jan. 20, '00	296	5704	12.81	3.87	730 4	221.0	257.9
Edna	980	5	Mid-sum.	July 9	342	7071	14.27	4.89	1009.2	345.6	403.2
Eulalie	1100	9	Nov. 12	Nov. 14	285	7187	13.89	4.74	998.5	340.7	397.5
Eva	880	6	Mid-sum.	July 4	318	6181	16.15	6.46	997.9	399.3	465.8
Fairie	900	9	March 9	March 21	325	6430	13.86	4.90	891.4	315.1	367.6
Flora	950	9	Sep. 27, '97	Feb. 7	266	7385	13.05	4.27	964.1	315.6	368.2
Goldenrod	1050	7	May 11	April 23	298	5379	15.59	6.19	834.4	333.0	388.5
Haidee	800	2	August 16	Dec. 1	335	4573	15.77	6.11	721.0	279.2	325.8
Hazel	630	2	Dec. 11	Killed	224	2540	14 96	5.54	380.0	140.7	164.1
Idarella	930	8	Feb. 16	Apr. 23	317	6068	14.06	5.01	853.1	303.9	354.6
Inez	780	6	Mid-sum.	Nov. 15	314	4155	15.65	6.09	650.1	253.1	295.3
Jersey Lily	950	7	May 10	*Mar. 23	346	3540	15.41	6.08	545.5	215.3	251.2
Lady Perusia 123228 A. J. C. C.	950	5	Oct. 10	Feb. 6, '00	365	5686	15.95	6.22	907.0	353.7	412.7
Leah	800	2	Nov. 22	Killed	341	3840	15.15	5 65	581.5	216.9	253.1
Lilac	700	2	....	Jan. 24	282	3727	13.97	4.72	520.5	175.8	205.1
Maizie	950	12	Nov. 23	....	340	7068	12.98	4.28	917.5	302.8	353.3
Max Belle 108996 A. J. C. C	980	6	*Aug. 7	*June 18	341	4514	15.68	6.05	707.9	273.3	318.9
Max Ella	950	7	Nov. 22	Jan. 10, '00	341	7742	13.45	4.58	1041.7	355.0	414.2
Minta Bella 85578 A. J. C. C	800	7	Jan. 10	*No. 6, '98	363	4953	16.21	6.60	802.9	326.7	381.2
Nancy B. 9581 A. R	1080	11	Nov. 6	Nov. 20	333	8344	12.74	4.00	1062.8	333.8	389.5
Naomi	800	3	Dec. 1, '97	Feb. 1	291	5573	13.94	4.71	776.3	262.6	306.4
Orpha	930	6	Mid-sum.	July 30	337	6138	13.98	4.56	857 8	279.6	326.2
Pauline	830	3	Dec. 16	Dec. 9	319	5894	13.85	4.67	816.6	275.5	321.4
Polela	900	4	Au. 20, '97	Jan. 10	292	5030	14.70	5.40	739.1	271.8	317.1
Polly	890	10	Sep. 18, '97	Feb. 8	296	5284	14.61	5.45	771.8	287.9	335.9
Pomona	850	7	July '97	Jan. 30	288	5875	14.38	5.38	844.8	315.8	368.5
Priscilla	900	3	Nov. 25	Nov. 13	311	4351	15.26	5.74	664.0	249.8	291.4
Pussy Willow	800	7	Sept. 6, '97	Jan. 22	29[illegible]	4564	15.06	5.68	687.0	259.1	302.3
Rachel	780	7	Oct. 5	Nov. 21	326	5216	15.47	6.02	807.1	314.1	366.5
Red Top	1050	9	Feb. 7	May 11	324	6700	12 70	4.03	851.3	269.7	314.7
Rose	700	3	Oct. 26	Killed	365	3893	14.73	5 46	573.3	212.7	248.2
Rowena	900	7	March 27	May 22	331	6440	13.61	4.52	876.5	291.1	339.6
Ruth	88[illegible]	3	Aug. 10	Sept 3	308	4298	14.13	4.75	607.3	204.1	238.1
Salida	980	5	Nov. 24 '97	Feb. 21	307	4526	14.33	5.17	648 4	233.9	272.9
Star Bright	800	2	Dec. 14	Nov. 5	252	3975	13.75	5.56	546.4	221.1	258.0
Suenette, 15731 A. R	1050	3	June 24	Aug. 23	306	6349	13.53	4.37	858.9	277.3	323.5
Sylvia	950	7	April 1	Aug. 12	300	4262	14.63	5.15	623.3	219.6	256.2
Viola	730	2	Jan. 3, '99	Feb. 20, '00	300	3960	14.36	5.18	568.4	205.2	239.4
Average of 47 Cows					312	5462	14.15	5 02	772.8	274.2	319.9
Average of 38 mature animals					315	5809	14.12	5.00	820.3	290.6	339.0
Average of 9 two-year-olds					300	3998	14.32	5.13	572.7	205.1	239.4

*Aborted.

HERD RECORD—Continued

Cow	Total cost of food	Total cost of purchased grain	Cost of food for 100 pounds of milk	Cost of food for 1 pound of fat	Cost of food for 1 pound of butter	Proceeds from butter sales at 26 cents per pound	Value of fertilizing ingredients in food fed in barn
	$	$	cts	cts	cts	$	$
Acme 5th, 10342 A. R	47.73	14.73	70.5	18.5	15.8	78.38	25.89
Adah	39 46	16.53	115.3	22.6	19.4	52.99	20.49
Atalanta, 10777 A. R	51.76	18.74	53.2	14.1	12.1	111.65	28.27
Bettie	53.40	17.90	90.6	19.4	16.6	83.46	27.82
Bonny Belle	39.85	15.85	94.0	18.8	16.1	64.20	18.73
Ceres	40.77	15 85	90.9	15.9	13.6	77.92	19.47
Clare	48.25	12.99	64.7	13 7	11.8	106.60	24.18
Clover	44.13	10.67	85.4	16.0	13.7	83.88	21.86
Dandelion	49.35	15.76	96.6	18.8	16.1	79.64	26.32
Dime, 15732 A. R	35.30	13.70	61.9	16.0	13.7	67.06	16 29
Edna	52.51	20.42	74.3	15.2	13.0	104.83	25.95
Eulalie	47.04	14.63	65 5	13.8	11.8	103.34	23.57
Eva	52 88	20.33	85 6	13.2	11.4	121.11	29 02
Fairie	45.84	15.51	71.3	14.5	12.5	95.58	22.42
Flora	45.26	12.85	61.3	14.3	12.3	95.74	23.51
Goldenrod	47.99	15.12	89.2	14.4	12 4	101.02	23.80
Haidee	46.62	18.91	101.9	16.7	14.3	84.72	25.73
Hazel	30.28	12.80	119.2	21.5	18.5	42.67	13.53
Idarella	48.58	18.93	80.1	16.0	13.7	92.20	24.20
Inez	47.63	14.59	114.6	18.8	16.1	76.78	25 59
Jersey Lily	48.08	15 83	135.8	22.3	19.1	65.31	23.24
Lady Perusia, 123288, A.J.C.C.	47.62	18.19	83.7	13.5	11.5	107.30	23.10
Leah	40.98	17 28	106.7	18.9	16.2	65 81	20.45
Lilac	31.29	12.32	84.0	17.8	15.3	53.32	14.73
Maizie	46.24	18.12	65.4	15.3	13.1	91.86	26.19
Max Belle, 108996, A. J. C. C	49.44	18 20	109.8	18.1	15.5	82.92	27.84
Max Ella	48.02	16.49	62.0	13.5	11.6	107.70	24.73
Minta Bella, 85578, A. J. C. C	46.26	18.58	93.4	14.2	12.1	99.11	22.81
Nancy B., 9581, A. R	56.44	18.26	67.6	16 9	14 5	101.28	31.27
Naomi	45.68	13.83	82.0	17.4	14.9	79.67	24.11
Orpha	50.29	20.77	81 9	18 0	15.4	84.82	25.38
Pauline	44.74	12.96	75 9	16.2	13.9	83.56	22.20
Polela	45.76	11.15	91.0	16.8	14.4	82.46	23.42
Polly	46.08	14.54	87.2	16.0	13.7	87.34	24.44
Pomona	45.14	13.26	76.8	14.3	12.3	95.82	23.90
Priscilla	42.22	11.17	97.0	16.9	14.5	75.77	21.22
Pussy Willow	45.77	12.78	100.3	17.7	15.1	78.60	23.06
Rachel	44.21	15.96	84.8	14.1	12.0	95.29	21.59
Red Top	48.37	15.04	72.2	17.9	15.4	81.82	24.18
Rose	37.99	13.91	97.6	17.9	15 3	64.54	18.07
Rowena	44.97	15.59	69.8	15.4	13.2	88.30	23.33
Ruth	44.47	14.52	103.5	21.8	18 7	61.90	23.07
Salida	46.20	15.12	102.1	19.8	16.9	70.96	24.32
Star Bright	32.32	13.51	81.3	14.6	12.5	67.08	16.49
Suenette, 15731 A. R	51.26	20.22	80.7	18.5	15 8	84.11	28.55
Sylvia	46.74	15.23	109.7	21.3	18.2	66.61	25 01
Viola	31.72	11.82	80.1	15.5	13.2	62.25	13.97
Average of 47 cows	45.17	15 57	86 6	16 9	14.5	83.18	23.13
Average of 38 mature animals	47.24	15.76	84.9	16.6	14 2	88.14	24.39
Average of 9 two-year-olds	36.43	14.74	93.8	18.0	15.5	62.24	17.83

RECORD OF THE HERD OF THE VERMONT AGRICULTURAL EXPERIMENT STATION FOR THE YEAR FROM NOV. 1, 1899, TO OCT. 31, 1900

Cow	Approximate weight	Age November 1, 1899	Calved, 1899	Calved, 1900	Days in milk	Milk	Total solids	Fat	Total solids	Fat	Butter
						lbs	%	%	lbs	lbs	lbs
Acme 5th, 10342 A. R.	950	10	Dec. 3	Dec. 22	311	7733	11.96	3.71	924.5	287.0	334.8
Atalanta, 10777 A. R.	1050	10	Nov. 16 '98	July 20	294	5508	12.31	3.72	677.9	204.9	239.0
Beaut. of Hert., 85928 A. J. C. C.	900	8	Sept.	Dec. 31	365	7089	14.75	5.32	1045.9	377.3	440.2
Buttercup	950	3	Aug. 28	Mch. 19 '01	365	4493	16.11	6.28	723.9	282.0	329.0
Ceres	850	9	Aug. 2	Nov. 22	305	6845	15.25	5.78	1044.3	395.7	461.6
Clare	1000	12	Jan. 22	June 4	310	5062	14.41	5.08	729.2	257.0	299.8
Cowslip	800	4	Oct. 14	Farrow	365	5834	14.74	5.59	860.1	326.2	380.6
Dahlia	850	8	Sept.	Dec. 27	365	6096	15.26	5.72	930.5	348.9	407.1
Dime, 15732 A. R.	880	3	Jan. 7	Jan. 20	309	6111	12.79	3.78	781.6	231.1	269.6
Edna	1000	6	July 9	June 22	365	5717	14.49	5.03	828.5	287.5	335.4
Eulalie	1130	10	Nov. 14	Farrow	350	8510	14.83	5.24	1261.8	445.5	519.8
Eva	880	7	July 4	Nov. 2	308	5030	17.54	7.27	882.3	365.9	426.9
Fairie	900	10	Mch. 21	June 5	316	5719	14.34	4.98	820.3	285.0	332.5
Flora	950	10	Feb. 7	Feb. 8	278	7521	13.22	4.49	994.1	337.7	304.9
Goldenrod	1080	8	Apl. 23	May 31	286	4556	16.60	6.75	756.4	307.5	358.7
Haidee	830	3	Dec. 1	Jan. 19 '01	365	6535	15.58	5.91	1018.4	386.4	450.8
Idarella	930	9	Apl. 23	Mch. 18 '01	365	6105	14.85	5.57	906 8	340.3	397.0
Inez	780	7	Nov. 15	Jan. 1 '01	349	6804	15.22	5.76	1035.8	392.2	457.2
Jersey Lily	950	8	Dec. 26	Dec. 27	319	5782	15.07	5.63	871.6	325.5	379.7
Lady Perusia, 123228 A. J. C. C.	970	6	Oct. 10 '98	Feb. 6	276	5559	15.30	5.81	850.5	322.8	376.6
Lilac	750	3	*Jan. 24	Mch. 26	312	4960	14.11	4.64	699.9	230 1	268.4
Max Belle, 108996 A. J. C. C.	1000	7	June 18	July 30	330	4659	15.94	6.14	742.8	286.0	333.6
Max Ella	980	8	Jan. 10 '00	Dec. 12	359	7348	14.28	4.99	1049.7	366.8	427.9
Minta Bella, 85578 A. J. C. C.	780	8	*Nov. 6 '98	Feb. 14	344	6860	15.09	5.72	1035.3	392.2	457.6
Mona	800	3	Apl. 23	May 30	329	6659	14.40	5.05	959.0	336.6	392.7
Nancy B, 9581 A. R.	1080	12	Nov. 20	Nov. 27	317	7776	12.31	3.75	957.0	291.6	340.2
Naomi	780	4	Feb. 1	Dec. 21	324	6620	14.17	4.65	938.4	307.9	359.2
Orpha	900	7	July 30	Oct. 5	267	3635	12.73	4.37	462.9	159.0	185.5
Pauline	830	4	Dec. 9	Apl. '01	330	6535	14.21	4.79	928.7	312.8	364.9
Polela	900	5	Jan. 10	Jan. 22	212	4050	14.66	5.33	593.6	216.0	252.0
Pomona	850	8	Jan. 30	Dec. 28 '99	349	6261	15 28	5.72	956.6	358.1	417.8
Pretoria	700	3	Oct.	Farrow	365	6768	14.43	4.94	976.9	334.6	390.4
Priscilla	950	4	Nov. 13	Feb. '01	348	5094	15.54	5.89	791.5	300.0	350.0
Pussy Willow	800	8	Jan. 22	Jan. 7	311	5225	15.19	5.66	793.7	295.9	345.2
Rachel	770	8	Nov. 21	Farrow	342	6472	15.33	5.69	992.1	368.2	429.6
Red Top	1030	10	May 11	June 1	283	7006	12.58	3.93	881.3	275.1	320.9
Rosemary	830	5	Oct.	Dec. 19	298	4644	14.46	5.04	671.1	233.9	272.8
Rowena	870	8	May 22	Farrow	365	5912	14.08	4.80	832.4	284.1	331.4
Ruth	880	4	Sept. 3	Jan. '01	365	4886	14.06	4.74	686 8	231.5	270.1
Salida	980	6	Feb. 21	Feb. 6	328	4537	14.57	5.17	660.9	234.4	273.4
Serena	700	3	Sept. 10	Jan. 4 '01	365	5353	14.72	5.17	788.2	276.7	322.8
Star Bright	800	3	Nov. 5	Dec. 24	356	5208	15.75	5.74	820.3	299.1	348.9
Suenette, 15731 A. R.	1050	4	Aug. 23	July 21	347	7554	13.51	4.36	1020.4	328.9	383.7
Sylvia	1000	8	Aug. 12	July 9	304	6422	14.21	4.81	912.4	309.0	360 5
Viola	750	3	Feb. 20 '00	Jan. 6 '01	333	4015	14.90	5.43	598.2	217.9	254.2
Average of 45 cows					328	5935	14.49	5.15	860.0	305.6	356.5

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* Aborted.

HERD RECORD—Continued

Cow	Total cost of food	Total cost of purchased grain	Cost of food for 100 pounds of milk	Cost of food for 1 pound of fat	Cost of food for 1 pound of butter	Proceeds from butter sales at 27¼ cents per pound	Value of fertilizing ingredients in food fed in barn
	$	$	cts	cts	cts	cts	$
Acme, 5th, 10342 A. R.	53.03	22.53	68.6	18.5	15.8	91.23	31 49
Atalanta, 10777 A. R.	51.79	21.21	94.0	25.3	21.7	65.12	30.91
Beaut. of Hert., 85921 A. J.C. C	59.60	25.12	84.1	15 8	13.5	119.96	35.77
Buttercup	51.62	19.01	114.9	18.3	15.7	89.65	29.35
Ceres	54.03	24.11	78.9	13.7	11.7	125.78	31.72
Clare	56.54	21.56	111.7	22.0	18.9	81.70	32.78
Cowslip	52.19	23.95	89.5	16.0	13.7	103.70	30 29
Dahlia	54.91	23.92	90.1	15.7	13.5	110.93	32.62
Dime, 15732 A. R.	49.51	17.94	81.0	21.4	18.4	73.46	27.19
Edna	58.00	25.06	101.5	20.2	17.3	91.40	34.66
Eulalie	68.42	29.15	80.4	15.4	13.2	141.64	39.80
Eva	50 62	21.34	100.6	13.8	11.9	116.32	28.12
Fairie	49.51	19.89	86.6	17.4	14.9	90.60	25.63
Flora	48.97	18.36	65.1	14.5	12.4	107.37	28.04
Goldenrod	54.93	18.79	120.6	17.9	15.3	97.74	29 43
Haidee	54.54	24.15	83.5	14.1	12.1	122.84	31.06
Idarella	56.55	23.55	92.6	16.6	14.2	108.19	34.09
Inez	52.36	22.23	77 0	13.4	11.5	124.60	29.67
Jersey Lily	53.53	22.71	92.6	16 4	14.1	103.46	31.45
Lady Perusia, 123228 A. J. C. C	48.29	16.79	86.9	15.0	12.8	102.62	27.93
Lilac	46.39	16.16	93.5	20.2	17.3	73.13	25.21
Max Belle, 108996 A. J. C. C	50.22	20.08	107.8	17.6	15.1	90.90	28.13
Max Ella	52.02	19.13	70.8	14.2	12.2	116.59	30.36
Minta Bella, 85578 A. J. C. C	51.14	19.88	74.5	13.0	11.2	124.69	28.88
Mona	53.13	20.96	79.8	15.8	13.5	107.01	31.02
Nancy B., 9581 A. R.	58.40	21.38	75.1	20.0	17.2	92.71	34.77
Naomi	52.81	21.50	79.8	17.2	14.7	97 89	30.73
Orpha	42.90	18.98	118.0	27.0	23.1	50.55	25 55
Pauline	52.40	21.59	80.2	16.8	14.4	99.43	31.48
Polela	40.77	13.47	100.7	18.9	16.2	68.68	23.45
Pomona	53.00	21.79	84.7	14.8	12.7	113.86	30.09
Pretoria	54.18	24.97	80.0	16.2	13.9	106.39	31.86
Priscilla	55.06	24.72	108.1	18.3	15.7	95.38	32.30
Pussy Willow	43.28	14.94	82.8	14.6	12.5	94.07	25.08
Rachel	48.84	21.70	75.5	13.3	11.4	117.07	29 06
Red Top	53.11	18.52	75.8	19.3	16.6	87 45	30.44
Rosemary	45.61	19.82	98 2	19.5	16.7	74.34	25.48
Rowena	56.28	24.35	95.2	19.8	17.0	90.31	29.47
Ruth	56.01	25.10	114.6	24.2	20.7	73.59	32.99
Salida	48.01	17.84	105 8	20.5	17.6	74.50	27.37
Serena	52.20	22.49	97.5	18.9	16.2	87.96	29.25
Star Bright	51.88	21.93	99.6	17.3	14.9	95.08	31.37
Suenette, 15731 A. R.	62.43	24.24	82.7	19.0	16.3	104.56	38.35
Sylvia	54.19	21.02	84.4	17.5	15.0	98.24	32.02
Viola	46.12	16.28	114.9	21.2	18.1	69.27	24.01
Average	52.43	21.20	90.7	17.7	15.2	97.15	30.24

RECORD OF THE HERD OF THE VERMONT AGRICULTURAL EXPERIMENT STATION FOR THE YEAR FROM NOV. 1, 1898, TO OCT. 31, 1899—Continued

Cow	Approximate weight	Age November 1, 1898	Calved, 1898	Calved, 1899	Days in milk	Milk	Total solids	Fat	Total solids	Fat	Butter
						lbs	%	%	lbs	lbs	lbs
Annie	800	3	Nov. 9	Sold	192	2823	13.53	4.28	382.4	121.1	141.3
Bess	900	12	Farrow	"	37	481	15.40	5.70	74.0	27.4	32.0
Brownie	950	9	*Sept. 10	"	175	1277	14.41	5.11	184.0	65.2	76.1
Buttercup	----	2	----------	Aug. 28	60	961	14.09	4.65	135.4	44.7	52.2
Carmen	950	9	Farrow	Sold	40	425	14.12	4.87	60.0	20.7	24.2
Dora	850	9	"	"	37	337	15.47	6.02	52.1	20.3	23.7
Flox	1000	8	"	Died	151	1600	14.08	4.84	225.2	77.5	90.4
Foolie	----	3	June 19	Sold	31	204	14.22	4.95	29.0	10.1	11.8
Goldie	1000	12	Aug. 10	"	205	4272	15.15	5.53	647.0	236.1	275.4
Jeannie	900	9	Mch. 16	Mch. 7	280	5185	13.17	4.44	682.8	230.4	268.8
Jip	----	--	----------	Mch.	209	3062	14.93	5.70	457.1	174.5	203.6
Lala	800	6	Nov. 12	Died	141	2709	13.92	4.70	377.0	127.2	148.4
Marjory	900	10	Farrow	"	244	3347	14.82	5.59	495.8	187.0	218.2
Nan	----	2	----------	Apl. 23	191	3948	13.62	4.79	537.9	189.3	220.9
Serena	----	2	----------	Sept. 16	48	804	13.66	4.39	109.8	35.3	41.2

HERD RECORD—Continued

Cow	Total cost of food	Total cost of purchased grain	Cost of food for 100 pounds of milk	Cost of food for 1 pound of fat	Cost of food for 1 pound of butter	Proceeds from butter sales at 26 cents per pound	Value of fertilizing ingredients in food fed in barn
	$	$	cts	cts	cts	$	$
Annie	28.89	11.87	102.2	23.9	20.4	36.74	16.22
Bess	5.79	3.45	120.4	21.1	18.1	8.32	3.35
Brownie	24.57	11.17	192.4	37.7	32.3	19.79	13.67
Buttercup	8.74	3.16	91.0	19.6	16.7	13.57	3.87
Carmen	6.33	3.44	148.9	30.6	26.2	6.29	3 43
Dora	4.71	2.89	139.8	23.2	19.9	6.16	2.61
Flox	25.61	14.22	160.1	33.0	28.3	23.50	13.87
Foolie	4.53	2.88	222.1	44.9	38.4	3.07	2.41
Goldie	34.96	14.65	81.8	14.8	12.7	71.60	22.39
Jeannie	41.07	14.33	79.2	17.8	15.3	69.90	20 60
Jip	26.09	9.27	85.2	15.0	12.8	52.94	11.30
Lala	21.04	8.24	77.7	16.5	14.2	38.59	11.77
Marjory	36.63	13.89	109.5	19.6	16.8	56.74	19.56
Nan	20.04	6.98	50.8	10.6	9.1	57.44	7.92
Serena	6.83	2.51	85.0	19.4	16.6	10.71	3.11

RECORD OF THE HERD OF THE VERMONT AGRICULTURAL EXPERIMENT STATION FOR THE YEAR FROM NOV. 1, 1899 TO OCT. 31, 1900—Continued

Cow	Approximate weight	Age November 1, 1898	Calved in 1898	Calved in 1898	Days in milk	Milk	Total solids	Fat	Total solids	Fat	Butter
						lbs	%	%	lbs	lbs	lbs
Adah	750	3	Nov 22,'98	April 1	187	1719	13.11	4.55	225.4	78.2	91.2
Bettie	980	11	March 1	Killed	330	6236	13.68	4.64	853.0	289.2	337.4
Bonny Belle	900	3	Dec. 4,'98	Killed	48	368	13.43	4.46	49.4	16.4	19.1
Clover	1000	12	March 1	Killed	147	1855	16.81	6.57	311.8	121.9	142.2
Dandelion	850	10	Feb. 28	Killed	147	2016	16.19	6.48	326.3	130.6	152.4
Edith	---	2	....	July 24	127	1907	14.56	5.03	277.6	95.9	111.9
Eunice	----	2	....	Aug. 13	77	1647	13.54	4.32	222.9	71.1	83.0
Jip	880	5	March	Killed	171	2198	15.91	6.09	349.6	133.8	156.1
Ladysmith	850	6	Sept.	Killed	280	5691	15.28	5.24	869.7	298.1	347.8
Maizie	970	13	Nov 23,'98	Killed	209	2733	13.82	4.74	377.7	129.4	151.0
Nan	----	2	....	July 14	105	1951	13.94	4.64	272.0	90.5	105.6
Polly	900	11	Feb. 8	Killed	302	3073	14.70	5.35	451.6	164.5	191.9
Sadie	----	2	....	May 22	161	2383	13.95	4.81	332.4	114.6	133.7
Shamrock	----	5	Sept.	Killed	161	1808	15.82	5.80	285.9	104.9	122.4

HERD RECORD—Continued

Cow	Total cost of food	Total cost of purchased grain	Cost of food for 100 pounds of milk	Cost of food for 1 pound of fat	Cost of food for 1 pound of butter	Proceeds from butter sales at 27¼ cents per pound	Value of fertilizing ingredients in food fed in barn
	$	$	cts	cts	cts	$	$
Adah	25.69	8.21	149.5	32.9	28.2	24.85	15.52
Bettie	58.70	29.79	94.1	20.3	17.4	91.93	33.94
Bonny Belle	7.56	3.11	205.4	46.1	39.6	5.20	3.87
Clover	26.89	11.11	145.0	22.1	18.9	38.75	15.09
Dandelion	25.65	9.95	127.2	19.6	16.8	41.53	14.42
Edith	16.58	6.12	86.9	17.3	14.8	30.49	6.88
Eunice	12.52	3.37	76.0	17.6	15.1	22.62	4.81
Jip	33.54	16.14	152.5	25.1	21.5	42.54	20.65
Ladysmith	47.91	19.53	84.2	16.1	13.8	94.79	27.74
Maizie	31.29	16.07	114.5	24.2	20.7	41.15	18.81
Nan	15.62	4.86	80.1	17.3	14.8	28.78	11.03
Polly	48.82	18.96	158.9	29.7	25.4	52.30	27.89
Sadie	19.22	8.01	80.7	16.8	14.4	36.44	8.77
Shamrock	26.88	10.86	148.7	25.6	22.0	33.35	22.23

AVERAGE DAIRY HERD RECORD FOR SIX YEARS, 1895-1900

NAME	Years of record	Pounds of milk	Test	Pounds of butter	Total cost of food	Cost of purchased grain	Cost of food for 1 lb. of butter in cents	Proceeds from butter sales, 23-27½ cts. per pound	Pounds of butter each year					
									1895	1896	1897	1898	1899	1900
Acme 5th 10342 A. R.	6	7523	3.87	340	$49.89	$17.36	14.8	$84.40	383	386	340	294	†302	335
Adah*	1	3422	5.11	204	33.46	16.53	19.4	52.99	----	----	----	----	204	----
Annie*	1	2344	4.74	130	36.62	11.18	28.2	33.42	----	----	----	130	----	----
Atalanta 10777 A. R.	6	7093	3.76	311	48.51	17.79	16.1	77.56	298	315	314	272	429	239
Beautina 85928 A. J. C. C.	1	7089	5.32	440	59.60	25.12	13.5	119.96	----	----	----	----	----	440
Besette*	1	5422	5.45	345	28.27	8.53	8.2	79.30	----	345	----	----	----	----
Bess*	4	6445	5.47	411	52.42	19.98	12.9	98.73	462	406	425	349	----	----
Bettie*	5	5791	4.77	321	49.56	18.36	15.8	80.19	†281	†396	†245	347	321	----
Bonny Belle*	1	4241	4.99	247	39.85	15.85	16.1	64.20	----	----	----	----	247	----
Brownie*	4	5811	5.31	360	47.32	15.92	13.6	86.28	331	459	357	293	----	----
Buttercup	1	4493	6.28	329	51.62	19.01	15.7	89.65	----	----	----	----	----	329
Carmen*	1	4808	4.76	267	54.21	20.71	20.3	68.82	----	----	----	267	----	----
Ceres	3	5907	5.69	400	47.72	18.65	12.1	105.41	----	----	----	437	300	462
Clare	3	5928	5.01	344	52.09	17.32	15.6	90.41	----	----	----	322	410	300
Clover*	5	4481	6.03	314	48.13	16.48	15.9	76.62	258	423	304	†263	323	----
Cowslip*	1	5834	5.59	381	52.19	23.95	13.7	103.70	----	----	----	----	----	381
Cressy*	2	4818	5.48	308	39.08	13.90	13.6	72.71	----	299	316	----	----	----
Dahlia	1	6096	5.72	407	54.91	23.92	13.5	110.93	----	----	----	----	----	407
Dandelion*	5	5449	5.48	348	46.50	16.46	13.5	85.28	301	365	402	368	306	----
Dime 15732 A. R	2	6908	3.83	264	42.41	15.82	16.1	70.26	----	----	----	----	258	270
Dora*	4	4783	5.63	314	44.87	17.96	14.3	75.79	369	†255	325	307	----	----
Edna	2	6394	4.96	369	55 26	22.74	15.2	98.12	----	----	----	----	403	335
Effie*	1	5004	4.49	262	43.29	16.68	16.5	60.30	----	----	262	----	----	----
Eulalie*	6	6279	4.95	364	50.92	17.76	14.7	91.13	371	396	294	203	398	519
Eva	2	5606	6.87	447	51.75	20.88	11 7	118.72	----	----	----	----	466	427
Fairie	6	6064	5.17	366	46.15	17.35	12.8	91.12	338	337	459	363	368	333
Fanny*	2	3448	5.17	208	44.61	16.81	11.7	48.45	245	171	----	----	----	----
Flora	6	6270	4.81	349	45.83	16.49	13.7	88.07	264	219	399	450	368	394
Flox*	3	5277	4.65	286	45.44	17.59	16.5	69.49	----	†346	†202	310	----	----
Goldenrod	6	5320	6.35	393	50.28	17.35	12.9	97.77	415	391	430	374	389	359
Goldie*	4	5366	5.50	344	50.68	18.59	15.0	83.18	356	275	396	349	----	----
Haidee	2	5554	6.01	389	50.58	21.53	13.2	103.78	----	----	----	----	326	451
Hazel*	1	2540	5.54	164	30.28	12.80	18.5	42.67	----	----	----	----	164	----
Helena*	1	2267	5.99	159	33.15	12.79	20.9	38.44	----	----	----	159	----	----
Idarella	5	6210	5.21	377	49.92	19.24	13.3	95.36	----	356	401	378	355	397
Inez	2	5480	5.93	376	50.00	18.41	13.8	100.70	----	----	----	----	295	457
Jeannie*	4	5579	4.92	320	46.36	17.70	15.7	76.94	188	417	373	300	----	----
Jersey Lily*	6	5346	5.66	351	48.27	17.34	14.1	87.41	342	370	411	352	†251	380
Jessaline*	2	4497	4.70	248	46.28	17.24	19.8	57.82	314	182	----	----	----	----
Jessie*	2	6063	5.78	408	48.64	16.35	12.0	94.93	458	358	----	----	----	----
Julia*	2	4962	5.79	334	43 25	16.38	13.0	77.65	347	321	----	----	----	----
Kinkora*	2	4264	5.45	269	43.04	15.16	16.1	62.52	292	246	----	----	----	----
Kittie*	2	4067	5.51	262	46.55	16.37	17.8	61.84	----	249	274	----	----	----
Lady Le Brocq*	2	4726	5.94	324	41.02	14.72	12.7	75.43	383	264	----	----	----	----
L'dyPerusia123228A.J.C.C	3	4745	6.01	333	45.87	16.71	14.7	87.96	----	----	----	210	413	377
Lala*	1	3950	5 20	240	40.02	13.09	16.7	61.74	----	----	----	240	----	----
Leah*	1	3840	5.65	253	40.98	17.28	16.2	65.81	----	----	----	----	253	----
Lilac	2	4343	4.68	237	38.84	14.24	16.3	63.23	----	----	----	----	205	268
Maizie*	5	5454	4.70	297	45.56	17.34	16.6	72.80	355	194	415	†169	353	----
Marjory*	3	5888	5.26	361	46.61	17.00	13.2	88.29	----	335	293	454	----	----
Max Belle 108996 A. J.C.C.	5	3866	6.25	281	44.34	16.62	15.9	71.39	----	†262	262	230	319	334
Max Ella	3	6870	4.79	384	49 70	17.46	13.2	101.25	----	----	----	309	414	428
Minta Bella 85578 A.J.C.C.	5	5665	6.16	405	44.74	16.23	11.0	102.49	----	†345	450	390	381	458
Mona	1	6659	5.05	393	53.13	20.96	13.5	107.01	----	----	----	----	----	393
Nancy B. 9481 A. R	6	7744	3.93	355	52.39	18.38	14 9	88.71	356	288	416	340	390	340
Naomi (2-yr-old)	3	5851	4.65	317	47.08	16.66	14.8	83.79	----	----	----	287	306	359
Nett*	2	7680	4.02	360	50.06	16.63	14.0	83.85	393	327	----	----	----	----
Orpha	2	4887	4.47	256	46.60	20.88	19.3	67.69	----	----	----	----	326	186
Pauline (2-yr-old)	3	5981	4.75	332	46 32	16.44	13.9	87.52	----	----	----	309	321	365
Polela	3	4616	5.51	298	45.38	14.09	15.3	78.11	----	----	----	323	317	252

HERD RECORD—Continued

NAME	Years of record	Pounds of milk	Test	Pounds of butter	Total cost of food	Cost of purchased grain	Cost of food for 1 lb. of butter in cents	Proceeds from butter sales, 23-27¼ cts. per pound¶	Pounds of butter each year					
									1895	1896	1897	1898	1899	1900
Portellette*	2	6674	4.46	363	$48.28	$16.26	13.6	$84.19	342	383	----	----	----	----
Polly*	2	5830	5.49	374	48.35	15.41	13.0	106.65	----	----	----	412	336	----
Pomona	3	6345	5.55	411	49.26	17.43	12.0	108.20	----	----	----	446	369	418
Pretoria	1	6768	4.94	390	54.18	24.97	13.9	106.39	----	----	----	----	----	390
Priscilla (2-yr-old)	3	4464	5.84	304	48.03	17.59	15.8	80.36	----	----	----	272	291	350
Pussy Willow	3	4875	5.69	324	46.35	14.77	14.3	85.37	----	----	----	324	302	345
Rachel*	3	5516	5.86	377	45.13	17.47	12.0	49.33	----	----	----	333	367	430
Red Top	6	6778	4.29	339	51.65	16.89	15.7	84.25	284	358	460	294	315	321
Regina*	3	5693	4.05	270	47.22	18.18	17.9	63.37	268	311	230	----	----	----
Rhoda*	1	5015	4.87	285	48.40	18.21	17.0	66.93	285	----	----	----	----	----
Rose*	2	3464	5.61	226	36.54	12.41	16.3	58.51	----	----	----	204	248	----
Rosemary	1	4614	5.04	273	45.61	19.82	16.7	74.34	----	----	----	----	----	273
Rowena	6	6175	4.58	330	49.63	17.52	15.6	82.38	211	384	360	351	340	331
Ruth*	3	4468	4.80	249	48.68	18.96	19.5	65.78	----	----	----	240	238	270
Salida*	4	3815	5.18	230	44.54	16.33	22.4	60.10	----	----	99	275	273	273
Serena	1	5353	5.17	323	52.20	22.49	16.2	87.96	----	----	----	----	----	323
Star Bright	2	4592	5.65	304	42.10	17.72	13.7	81.08	----	----	----	----	258	349
Suenette 15731 A. R.	2	6952	4.37	354	56.85	22.23	16.1	94.34	----	----	----	----	324	384
Sylvia	2	5342	4.98	309	50.47	18.12	16.6	82.43	----	----	----	----	256	361
Viola	2	3988	5.31	247	38.92	14.05	15.7	65.76	----	----	----	----	239	254
Waxy*	1	4892	4.74	270	43.19	17.39	15.9	63.94	270	----	----	----	----	----
	‡													
Average record for 1895	33	5633	4.95	325	50.06	18.85	16.2	76.40						
" " for 1896	37	5431	5.12	324	42.00	14.22	13.8	74.51						
" " for 1897	29	5730	5.06	338	47.45	18.69	15.3	82.04						
" " for 1898	42	5296	5.06	313	46.40	15.73	15.6	80.58						
" " for 1899	47	5462	5.02	320	45.17	15.57	14.5	83.18						
" " for 1900	45	5935	5.15	357	52.43	21.20	15.2	97.15						

* Cows not now at farm, mostly killed,

† Aborted.

‡ Number of cows.

¶ Average receipts for butter, 1894-95, 2 ½ cts.; 1895-96, 23 cts.; 1896-97, 24¼ cts.; 1897-98, 25¾ cts.; 1898-99, 26 cts.; 1899-1900, 27¼ cts.

The herd, as a whole, made the most milk and butter to the cow during 1899-1900. The butter was made more cheaply during 1895-96. Yet, owing to better selling prices, the financial showing is best during the past year. The excess of proceeds per cow over total cost of food for the six years respectively, is $26.34, $32.51, $34.59, $34.18, $38.01 and $44.72. The more favorable results of the later years, are entirely due to better selling prices.

The following tables show extremes of quantity, quality, cost of production, etc., during each of the two years.

EXTREMES OF PRODUCTION

1898–1899

	Lowest amount for any cow		Highest amount for any cow		Ratio of lowest to highest
Pounds of milk	2540	Hazel	9740	Atalanta	1 : 3.84
Per cent of total solids	11.94	Acme	16.21	Minta Bella	1 : 1.36
Per cent of fat	3.78	Atalanta	6.60	" "	1 : 1.75
Pounds of total solids	380.0	Hazel	1205.4	Atalanta	1 : 3.17
Pounds of fat	140.7	"	399.3	Eva	1 : 2.83
Pounds of butter	164.1	"	465.8	"	1 : 2.84
Cost of feed	$30.28	"	$56.44	Nancy B	1 : 1.87
Cost of grain	$11.15	Polela	$20.77	Orpha	1 : 1.86
Cost of 100 pounds of milk	53.2 cts.	Atalanta	135.8 cts.	Jersey Lily	1 : 2.55
Cost of 1 pound of fat	13.2 "	Fairie	22.6 "	Adah	1 : 1.71
Cost of 1 pound of butter	11.4 "	"	19.4 "	"	1 : 1.70
Value of butter at actual selling price	$42.67	Hazel	$121.11	Eva	1 : 2 84
Value of fertilizing ingredients in food	$13.53	Hazel	$ 31.27	Nancy B	1 : 2.32

1899–1900

Pounds of milk	3635	Orpha	8510	Eulalie	1 : 2.35
Per cent of total solids	11.96	Acme	17.54	Eva	1 : 1.47
Per cent of fat	3.71	"	7.27	"	1 : 1.96
Pounds of total solids	462.9	Orpha	1261.8	Eulalie	1 : 2.73
Pounds of fat	159.0	"	445.5	"	1 : 2.80
Pounds of butter	185.5	"	519.8	"	1 : 2.81
Cost of feed	$40.77	Polela	$68.42	"	1 : 1.68
Cost of grain	$13.47	"	$29.15	"	1 : 2.16
Cost of 100 pounds of milk	65.1 cts.	Flora	118.0 cts.	Orpha	1 : 1.81
Cost of 1 pound of fat	13.0 "	Minta Bella	27.0 "	"	1 : 2.08
Cost of 1 pound of butter	11.2 "	" "	23.1 "	"	1 : 2.07
Value of butter at actual selling price	$50.55	Orpha	$141.64	Eulalie	1 : 2.80
Value of fertilizing ingredients in food	$23.45	Polela	$ 39.80	"	1 : 1.70

These extremes are wide. It cost nearly twice as much for food to make a pound of butter from the cows which tailed the lot each year than from those which led it. Yet the cow Hazel making 164 pounds of butter the first year and the cow Orpha yielding but 186 pounds the second year, the end of the processions, made each of them more butter than the average Vermont cow is thought to make. The owners of cows that do no better than this are not making much out of dairying, but—as it has been aptly said—are presumedly milking the cows for the fun of it or for the pleasure of their company. The station, although more amply endowed than are most dairymen, felt that the fun of milking Hazel and the benefit of associating with her were not great enough to warrant keeping her; and she went promptly to the shambles, where others like her have gone, and where tens of thousands of Vermont cows ought go.

The following tables shows the feeding record of each cow which was a member of the herd within either record year. All of the cows were out to pasture each year for about five and one-half months, but were housed over night during this time. They were fed twice daily the year around, grained during the summer to some extent, watered in winter twice a day, and turned out in the winter for from 20 to 40 minutes daily except in extreme weather. The station herd is used in feeding experiments for from six to seven months, during which time the cows are subjected to many changes in ration. In some cases materials may be fed which are distasteful, and, frequently, wasteful or ill-balanced rations are used. These changes, necessitated by the conduct of feeding experiments, are obviously not conducive to the largest production. At no time was special effort made to select or to feed the most economical ration, or to force any cow to a maximum production.

With the exception of the registered animals, and some of the younger animals which were raised by the station, these cows are "farmers' cows," bought by a Vermont farmer at moderate prices, from farmers' herds within the limits of two contiguous Vermont towns. It is clear that such cows are better worth $50.00, the approximate average price paid, than is the average Vermont cow, which gives but little over 150 pounds of butter a year, worth a quarter of that sum. It is quite practicable for a good judge of cows to get together such a herd by the expenditure of some time, trouble and a moderate amount of money. It is hoped that the study of this record by Vermont farmers will lead many to breed better cows, to feed good cows better, and to cull out unprofitable animals.

FEEDING RECORD, NOVEMBER 1, 1898—OCTOBER 31, 1899

NAME OF COW	Hay	Corn silage	Beets	Artichokes	Artichoke tops	Green oats, barley, hungarian	Green rowen	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Buffalo gluten feed (a) Buckwheat middlings (b) Quaker oat feed (c)
	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
Acme	4009	4595	69	661		408	899	348	485	206	582(a)
Adah	2013	3929		898		349	747	525	827	261	286(b)
Annie	2815	2899	(89	lbs	oil)			742	741		
Atalanta	3774	6030				407	921	421	558	207	880(a)
Beautina of Hillcrest	267	693						98	97		
Bess	289	489	123	80				216	215		
Bettie	4355	5950				393	925	697	764	198	222(b) 212(c)
Bonny Belle	2134	4329		816		373	744	991	991		
Brownie	2551	541	620	77	40			698	698		
Buttercup	423	1055				114	285	198	197		
Carmen	568		221					215	215		
Ceres	2634	4265	(87	lbs	oil)	234	884	991	990		
Clare	4562	4420	730			412	929	812	812		
Clover	4434	3599		590		407	935	513	512		324(c)
Cowslip	175	374						24	24		
Dahlia	269	553						74	74		
Dandelion	5287	1409				400	922	504	654	242	138(b) 360(c)
Dime	1926	3983	(50	lbs	oil)	407	903	857	856		
Dora	343			106	82			181	180		
Edna	3609	5897	(89	lbs	oil)	425	907	1276	1276		
Eulalie	4133	4988	(87	lbs	oil)	284	595	914	914		
Eva	3726	5876				397	912	511	697	278	763(a)
Fairie	3628	4763				377	869	624	651	80	524(c)
Flora	4318	4001				403	916	477	549	216	236(c)
Flox	2137	534	606	37				889	888		
Foolie	326		118					180	180		
Goldenrod	4213	4609				402	932	836	835		212(c)
Goldie	2981	4598						97	285	285	852(a)
Haidee	2861	5459				358	744	344	563	332	798(a)
Hazel	1661	2422	385			242	299	800	800		
Idarella	4168	2230		371		396	916	1184	1183		830(a)
Inez	5310	1473				382	896	464	368		105(b)
Jeannie	4139	745				398	919	485	576	104	440(c)
Jersey Lily	3781	5508				399	919	720	719		523(c)
Jip	1374	2443				397	922	580	579		
Lady Perusia	2957	5185		906		402	916	1137	1136		
Ladysmith	264	530						65	64		
Lala	1953	2668	(87	lbs	oil)			515	515		
Leah	2191	3980	794			369	746	818	911	277	
Lilac	1682	3170				339	755	771	770		
Maizie	4456	1529			117	393	926	599	854	312	298(b)
Marjory	3057	5004	(87	lbs	oil)			867	867		
Max Belle	3600	5338				418	927	464	878	611	
Max Ella	3922	4595				398	920	713	911		400(b)
Minta Bella	2580	5932			160	394	920	663	765	206	558(c)
Mona	802	1842				347	780	437	436		
Nancy B.	4512	7218				407	931	450	668	330	552(a)
Naomi	4281	3429		573		368	760	560	707	156	189(b)
Orpha	4230	2514				249	893	1171	1170		227(b)
Pauline	4116	1459	2917			357	769	515	442		554(a)
Polela	4432	4378	735			407	927	482	406		421(a)
Polly	4126	3509		488		397	925	640	734	285	
Pomona	4315	3210		468		384	911	595	676	248	
Pretoria	278	577						54	54		

FEEDING RECORD—Continued

NAME OF COW	Hay	Corn silage	Beets	Artichokes	Artichoke tops	Green oats, barley, hungarian	Green rowen	Corn meal	Wheat bran	½ cottonseed meal ¼ linseed meal	Buffalo gluten feed (a) Buckwheat middlings (b) Quaker oat feed (c)
	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
Priscilla	3923	1388	2914			393	898	483	372		549(a)
Pussy Willow	4452	3371		617		396	910	799	799		
Rachel	3248	4396			35	408	911	998	998		
Red Top	4086	5302	(87	lbs	oil)	409	915	940	940		
Rose	2646	3695				327	745	869	869		
Rosemary	263	494						96	95		
Rowena	3877	4641	(87	lbs	oil)	395	920	975	974		
Ruth	4204	1841		1818		103	256	617	520		556(a)
Salida	4352	3038				384	910	660	800	153	175(b)
Serena	348	926				68		131	187		
Shamrock	268	680						60	59		
Star Bright	1647	3334		89		289	559	179	184		1117(a)
Sue	3506	6269				115	448	395	602	312	887(a)
Sylvia	5074	1291				269	903	509	413		821(a)
Viola	1814	3372				357	758	523	533		409(c)

FEEDING RECORD, NOVEMBER 1, 1899–OCTOBER 31, 1900

NAME OF COW	Hay	Corn silage	Grass	Rowen	Alfalfa and hungarian	Oat fodder	Corn meal	Wheat bran	Cottonseed meal	Linseed meal	Buffalo gluten feed (1) Buckwheat middlings (2) Quaker dairy feed (3)
	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
Acme	2884	5867	569	273	199	480	487	1133	307	299	
Adah	1948	5163					334	433	50	50	
Atalanta	2533	6829	564	575	185	462	493	1080	273	264	
Beautina of Hillcrest	2918	7663	825	575	249	613	561	1278	331	322	
Bettie	2738	5732	553		75	455	856	1542	317	309	
Bonny Belle	460	1433					123	123			10(3)
Buttercup	2902	6878	574	579	200	469	666	824	38	30	449(2)
Ceres	2545	7084	473		93	478	440	1121	330	322	
Clare	3293	6572	643	579	248	615	636	1143	216	207	
Clover	1656	4999					608	609			18(3)
Cowslip	2525	5871	530	568	103		499	1141	297	289	
Dahlia	2497	7175	568	579	196	477	535	1232	310	301	
Dandelion	1729	4700					362	381	9	9	336(3)
Dime	2825	6465	572	576	196	482	406	716	124	116	521(3)
Edith	560	562	535	568	105		292	344	10	2	
Edna	2834	7355	573	570	198	480	561	1270	331	323	

FEEDING RECORD—Continued

NAME OF COW	Hay	Corn silage	Grass	Rowen	Alfalfa and hungarian	Oat fodder	Corn meal	Wheat bran	Cottonseed meal	Linseed meal	Buffalo gluten feed (1) Buckwheat middlings (2) Quaker dairy feed (3)
	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
Eulalie	3748	7806	823	817	278	612	450	1226	39	31	1185(1)
Eunice	307	585	476	574	103		155	208	8		
Eva	2468	6826	474	97	90	474	347	751	216	207	657(3)
Fairie	2723	5610	551	574	179	415	703	831	39	27	579(3)
Flora	2682	6352	569	576	187	459	526	974	189	181	
Goldenrod	3510	6946	572	579	195	467	708	883	39	31	394(3)
Haidee	2466	6900	573	576	187	471	502	1158	298	290	
Idarella	2837	7395	560	578	203	477	527	933	174	165	562(2)
Inez	2863	5392	569	570	195	478	394	929	39	31	*34(2)
Jersey Lily	2822	6058	547	560	179	463	461	1015	252	244	4(2)
Jip	2253	4088					183	530	173	172	577(3)
Lady Perusia	2885	6223	572	575	199	477	435	879	193	185	
Ladysmith	2458	5975				419	342	960	302	293	
Lilac	2857	6273	337	576	105		623	929	74	66	4(3)
Maizie	1597	4820					168	472	152	152	702(3)
Max Belle	2802	5899	567	553	188	213	332	724	193	185	624(3)
Max Ella	2777	7555	568	554	185	468	473	992	231	223	
Minta Bella	2789	6397	561	574	196	475	489	968	211	202	15(3)
Mona	2609	7131	749	673	232	568	579	1010	164	156	232(2)
Nan	680	559	335	574	103		241	288	8		
Nancy B	3672	7339	822	40	282	621	469	1075	289	281	
Naomi	2462	7538	572	573	180	468	461	1020	259	249	
Orpha	2359	4216		537			282	936	306	305	
Pauline	2519	6981	568	584	195	477	490	1105	280	270	
Polela	2541	6165				223	206	663	219	211	
Polly	2808	6082		566	89	475	443	907	236	228	8(3)
Pomona	2787	6377	567	577	189	469	348	909	39	31	861(1)
Powella	541	268					25	50			
Pretoria	2857	4798	559	580	199	473	524	1193	310	301	
Priscilla	2749	5944	567	561	181	476	506	1181	311	302	
Pussy Willow	2395	5791	570	549	197	466	327	691	39	31	458(2)
Rachel	2483	4675	560	575	193	474	446	974	47	39	735(2)
Red Top	3087	6784	824	638	280	617	593	995	165	157	
Rosemary	2473	4755	295		88	473	215	745	39	31	924(1)
Rowena	2713	7130	557	571	190	466	900	1093	55	46	564(3)
Ruth	2867	6630	339	574	103		506	1180	329	321	
Sadie	797	472	336	569	103		328	460	39	31	
Salida	2839	5988	334	577	103		804	1046	38	30	467(2)
Serena	2803	5661	567	577	167	468	465	907	193	184	6(3)
Shamrock	1860	4479					34	394	76		568(2)
Star Bright	2476	6552	572	579	206	472	385	935	39	31	861(2)
Sue	3651	7644	818	671	278	541	480	960	204	196	569(2)
Sylvia	2811	7020	824	672	279	612	518	1075	259	250	
Viola	2755	6363	333	575	104		569	702	39	31	436(3)

* Also 814 (1)

NOTE—The Atlantic gluten flour, sugar and palm oil fed to 10 cows, (see pages 417-420, also appendix) do not appear in this table.

APPENDIX CONTAINING CONDENSED DATA PERTAINING TO ARTICLE ON FEEDING TRIALS WITH COWS

I. Weights of cows.
II. Average barn temperatures, with ranges and percentages of uniformity.
III Analyses and digestible ingredients in fodders and feeds: (*a*) analyses on dry basis; (*b*) digestion co-efficients; (*c*) pounds of digestible nutrients in 100 pounds of original substance.
IV. Feeding records of the individual cows in feeding tests.
V. Production records; showing production and same per unit for each individual cow in feeding tests.
VI. Difference tables: (*a*) Total of differences; (*b*) percentage differences.
VII. Results of experimental feeding on different rations.

I. WEIGHTS OF COWS

Period	Beautina	Dahlia	Acme	Nancy B	Rosemary	Eulalie	Pomona	Inez	Star Bright	Rachel
I begin	895	845	---	----	775	----	---	---	746	---
I end	885	857	955	1095	795	1062	---	777	756	745
II	890	857	913	1048	810	1070	858	777	785	762
III	890	832	898	1032	783	1073	830	725	775	745
IV	892	846	957	1078	842	1161	845	798	817	762
V	903	857	910	1082	842	1187	850	785	815	773
VI	940	845	942	1106	842	1178	878	793	835	782
VII	930	853	992	1115	827	1105	868	---	---	---

Period	Pussy Willow	Ceres	Cowslip	Haidee	Ladysmith	Naomi	Pauline	Pretoria	Priscilla	Ruth
I begin	---	838	735	---	808	---	---	660	---	846
I end	---	822	755	829	825	---	-	648	898	867
II	---	857	779	816	851	782	813	662	940	883
III	785	790	782	780	828	735	794	671	910	853
IV	797	847	795	828	868	770	833	692	980	900
V	782	875	800	843	878	775	865	720	982	603
VI	795	900	792	840	896	812	865	720	965	923
VII	---	858	825	833	895	797	868	735	968	888

Period	Jersey Lily	Idarella	Mona	Suenette	Buttercup	Serena	Dime	Eva	Jip	Maizie
I begin	---	948	783	1035	863	660	---	---	885	---
I end	---	919	778	1045	913	674	---	887	868	950
II	983	940	803	1008	920	690	---	880	872	958
III	954	885	815	975	945	710	830	843	820	914
IV	987	932	826	1098	993	735	878	883	910	958
V	970	930	873	1103	975	724	884	883	900	982
VI	948	963	---	1120	990	718	910	905	950	972
VII	893	---	---	1130	---	724	912	902	---	982

Period	Max Belle	Dandelion	Fairie	Goldenrod	Rowena	Viola	Bettie	Polela	Salida	Flora
I begin	933	---	---	1062	876	---	----	---	---	---
I end	955	843	883	1068	878	---	1002	---	---	---
II	985	828	879	1058	863	---	960	---	---	---
III	993	825	870	1058	818	---	956	863	---	---
IV	1015	848	935	1090	878	745	1022	915	983	950
V	1043	850	972	----	858	763	1000	898	970	958
VI	1044	---	---	----	862	755	980	928	995	940
VII	1022	---	---	----	862	754	----	938	998	931

Period	Lady Perusia	Max Ella	Minta Bella	Atalanta	Clare	Edna	Orpha	Red Top	Sylvia
I begin	---	---	---	975	955	940	---	1012	953
I end	---	---	---	988	995	944	868	1035	960
II	---	---	---	1000	992	955	890	1025	958
III	---	943	---	1005	1008	950	890	1060	963
IV	971	1030	780	1067	1055	1033	955	----	1075
V	948	990	780	1123	----	1043	947	----	1077
VI	978	995	790	1140	----	1060	973	----	1980
VII	983	983	778	----	----	1073	975	----	----

II. AVERAGE BARN TEMPERATURES, WITH RANGES AND PERCENTAGES OF UNIFORMITY

		5 AM	12 M	6 PM	5 AM	12 M	6 PM	5 AM	12 M	6 PM			5 AM	12 M	6 PM	5 AM	12 M	6 PM	5 AM	12 M	6 PM
		Large barn											Small barn								
I	Pre	52	50	52	45-58	47-53	50-55	60	100	100	I	Pre	50	49	51	44-58	44-54	46-54	60	50	100
	Exp	54	52	54	50-60	45-60	49-61	78	72	78		Exp	52	51	53	41-58	46-57	48-57	72	72	83
II	Pre	53	51	53	43-64	43-62	42-62	50	80	50	II	Pre	53	52	53	41-66	46-66	47-66	30	50	30
	Exp	52	50	52	45-59	44-54	47-56	50	67	67		Exp	52	54	54	36-60	41-58	44-58	39	78	89
III	Pre	52	49	50	42-60	41-53	45-55	50	60	80	III	Pre	53	51	53	45-60	44-56	48-57	40	80	80
	Exp	51	50	51	44-60	38-54	38-56	50	72	78		Exp	53	52	54	41-60	54-60	41-60	67	55	72
IV	Pre	52	48	52	42-58	42-54	45-58	50	60	60	IV	Pre	54	52	55	44-60	48-60	49-60	30	80	80
	Exp	53	51	52	44-60	38-57	45-58	61	72	72		Exp	53	55	55	36-63	45-62	45-60	44	78	78
V	Pre	52	50	52	45-60	42-55	49-55	50	50	100	V	Pre	52	54	55	38-64	45-58	53-58	20	40	100
	Exp	52	48	50	45-57	40-59	43-56	44	72	78		Exp	53	53	53	40-60	44-61	43-58	50	67	78
VI	Pre	57	54	55	54-62	52-58	53-58	90	80	100	VI	Pre	57	58	60	54-59	51-60	56-60	100	90	100
	Exp	59	58	59	52-68	50-70	46-70	67	44	44		Exp	58	60	61	47-68	50-72	54-72	50	28	44
VII	Pre	56	58	59	47-62	52-68	50-68	30	40	50	VII	Pre	53	61	62	44-60	51-70	54-70	70	50	70
	Exp	60	61	61	50-73	50-89	52-80	61	33	50		Exp	59	63	63	51-73	51-84	56-80	67	39	44

III. ANALYSES AND DIGESTIBLE INGREDIENTS IN FODDERS AND FEEDS

(*a*) ANALYSES ON DRY BASIS; (*b*) DIGESTION COEFFICIENTS; (*c*) POUNDS OF DIGESTIBLE NUTRIENTS IN ONE HUNDRED POUNDS OF ORIGINAL SUBSTANCE

(*a*) ANALYSES ON DRY BASIS

Fodders and feeds	Dates of sampling*	Original substance		Composition of dry matter							
		Water	Dry matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Nitrogen	Phosphoric acid	Potash
Hay	Nov. 13-29, Dec. 11-26	14.80	85.20	6.79	9.79	32.95	47.34	3.13	1.57	0.40	1.87
	Jan. 8-22, Feb. 5	16.92	83.08	7.12	12.03	27.85	49.36	3.64	1.92	0.46	1.78
	March 5-19, April 2-19	11.71	88.29	6.66	9.68	31.18	49.69	2.79	1.55	0.59	2.21
	April 30, May 14-21	9.99	90.01	7.41	10.73	29.38	48.89	3.59	1.72	0.54	2.46
Silage	Nov. 13-29, Dec. 26	73.08	26.92	6.86	9.30	23.45	56.88	3.51	1.49	0.64	1.89
	Jan. 8-22, Feb. 5	72.86	27.14	6.03	9.24	21.73	59.57	3.43	1.48	0.56	1.66
	March 19, April 2-19	72.29	27.71	6.40	9.00	22.99	58.12	3.49	1.44	0.58	1.70
	April 30, May 14	73.78	26.22	7.03	9.52	23.83	56.77	2.85	1.52	0.70	2.09
Silage †	December 11	78.05	21.95	7.66	10.76	22.41	56.09	3.08	1.72	0.64	1.76
	February 19	77.76	22.24	7.41	10.46	24.26	54.57	3.30	1.67	0.70	2.00
	March 5	79.10	20.90	9.58	11.90	26.07	48.74	3.71	1.90	0.62	2.00
Mixed feed No. 1 ‡	Nov. 13-29, Dec. 11-26	14.12	85.88	6.05	26.23	10.99	50.63	6.10	4.20	2.71	1.61
	Jan. 8-22, Feb. 5-19	13.74	86.26	6.10	26.40	11.25	49.91	6.34	4.21	2.78	1.79
	March 5-19, April 2-19	12.39	87.61	6.01	26.20	11.27	50.44	6.08	4.19	2.76	1.77
	April 30, May 14-21	13.00	87.00	6.00	26.66	11.23	49.89	6.22	4.27	2.99	1.79
Mixed feed No. 2 ‡	Nov. 13-29, Dec. 11-26	10.86	89.14	3.40	24.89	9.60	57.58	4.53	3.98	1.54	0.96
	Jan. 8-22, Feb. 5-19	10.75	89.25	3.39	24.20	9.76	58.13	4.52	3.87	1.62	0.98
	March 5-19, April 2-19	10.32	89.68	3.53	24.27	10.41	57.00	4.79	3.88	1.75	1.16
	April 30, May 14-21	11.33	88.67	3.61	24.53	10.17	57.13	4.56	3.92	1.90	0.95
Mixed feed No. 3 ‡	Nov. 13-29, Dec. 11-26	11.22	88.78	5.95	29.61	8.10	48.71	7.63	4.74	3.05	1.60
	Jan. 8-22, Feb. 5-19	10.75	89.25	5.54	29.77	9.28	47.68	7.73	4.76	2.94	1.61
	March 5-19, April 2-19	11.15	88.85	5.44	27.21	8.88	51.20	7.27	4.35	2.88	1.60
Mixed feed No. 4 ‡	Nov. 13-29, Dec. 11-26	11.32	88.68	4.11	14.37	8.13	68.10	5.29	2.30	1.88	1.30
	Jan. 8-22, Feb. 5-19	12.16	87.84	3.84	14.41	7.79	68.39	5.57	2.31	1.78	1.26
	March 5-19 April 2-19	12.44	87.56	3.88	14.00	7.52	69.28	5.32	2.24	1.76	1.16
	April 30, May 14-21	12.56	87.44	4.91	15.14	8.30	66.19	5.46	2.42	2.21	1.28

*** Samples were taken at fortnightly intervals, silages and hays in triplicate, grain feeds and mixtures, singly. The roughage and concentrate samples, 237 in number, were separately analyzed for dry matter and combined into 59 samples for complete analyses as indicated in the table. In calculating total dry matter and digestible ingredients eaten the analyses of the individual samples were used for the appropriate periods.**

† At three times during the winter the silage samples contained less dry matter than during the remainder of the trials. These samples were analyzed separately.

‡ The formulas for the mixed feeds are shown by footnote on page 404.

Fodders and feeds	Dates of sampling	Original substance		Composition of dry matter							
		Water	Dry matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Nitrogen	Phosphoric acid	Potash
Corn meal	Nov. 13-29, Dec. 11-26	12.35	87.65	1.57	10.76	2.93	79.58	5.16	1.72	0.65	0.49
	Jan. 8-22, Feb. 5-19	13.78	86.22	1.57	11.43	2.87	78.90	5.23	1.83	0.65	0.48
	March 5-19, April 2-19	13.47	86.53	1.48	11.38	2.27	79.77	5.10	1.82	0.70	0.48
	April 30, May 14-21	13.77	86.23	1.40	11.46	2.93	78.97	5.24	1.83	0.58	0.48
Wheat bran	Nov. 13-29, Dec. 11-26	10.97	89.03	6.75	16.73	12.78	58.32	5.42	2.68	3.24	2.02
	Jan. 8-22, Feb. 5-19	11.05	88.95	6.95	16.96	13.33	57.16	5.60	2.71	3.33	2.00
	March 5-19, April 2-19	10.37	89.63	6.29	17.41	12.92	57.64	5.74	2.79	3.42	2.07
	April 30, May 14-21	10.86	89.14	6.83	17.41	12.91	57.22	5.63	2.79	3.28	2.09
Cottonseed meal	Nov 13-29, Dec. 11-26	9.36	90.64	6.95	50.63	5.85	27.01	9.56	8.10	3.55	2.28
	Jan. 8-22, Feb. 5-19	8.64	91.36	7.32	51.04	5.41	27.20	9.03	8.17	3.84	2.31
	March 5-19, April 2-19	8.95	91.05	6.88	52.00	5.39	26.44	9.29	8.32	3.86	2.31
	April 30, May 14-21	9.82	90.18	6.77	51.40	5.58	27.13	9.12	8.22	3.71	2.27
Buffalo gluten feed	Nov. 13-29, Dec. 11-26	7.92	92.08	1.93	28.42	8.07	57.93	3.65	4.55	0.70	0.44
	Jan. 8-22, Feb. 5-19	8.47	91.53	1.87	28.24	8.10	57.78	4.01	4.52	1.06	0.48
	March 5-19, April 2-19	8.29	91.71	2.02	29.66	8.22	56.16	3.94	4.75	1.06	0.47
	April 30, May 14-21	8.63	91.37	2.06	29.02	8.52	56.05	4.35	4.64	0.85	0.47
Cleveland flax meal	Nov. 13-29, Dec. 11-26	11.50	88.50	5.57	39.58	11.42	38.86	4.57	6.33	1.76	1.56
	Jan. 8-22, Feb. 5-19	11.89	88.11	5.36	40.35	10.94	38.65	4.70	6.46	1.63	1.42
	March 5-19, April 2-19	11.61	88.39	5.45	40.10	11.17	38.55	4.73	6.42	1.67	1.52
	April 30, May 14-21	11.25	88.75	5.92	39.52	11.40	38.49	4.67	6.32	1.77	1.48
Buckwheat middlings	Nov. 13-29, Dec. 11-26	9.95	90.05	4.53	36.02	5.44	44.76	9.25	5.76	2.88	1.22
	Jan. 8-22, Feb. 5-19	10.09	89.91	4.88	35.64	5.54	44.80	9.14	5.70	2.75	1.44
	March 5-19, April 2-19	10.46	89.54	4.55	31.60	6.17	49.64	8.04	5.06	2.65	1.36
Quaker dairy feed	December 26	8.17	91.83	5.03	13.51	22.27	56.00	3.19	2.16	0.69	0.77
	Jan. 8-22, Feb. 5-19	7.60	92.40	4.97	14.20	19.79	57.59	3.45	2.27	0.69	0.81
	March 5-19, April 2-19	7.77	92.23	4.77	13.03	20.37	58.50	3.33	2.08	0.64	0.73
	April 30, May 14-21	8.28	91.72	4.59	13.51	21.18	57.42	3.30	2.16	0.57	0.62
Atlantic gluten flour	December 26	7.88	92.12	0.91	88.92	0.30	8.35	1.52	14.23	0.49	0.12
	Jan. 8-22, Feb. 5-19	7.80	92.20	1.01	88.70	0.11	8.66	1.52	14.19	0.57	0.12
	March 5-19, April 2-19	8.05	91.95	1.05	88.05	0.16	8.57	2.17	14.09	0.49	0.13
	April 30, May 14-20	7.63	92.37	1.18	87.10	0.16	8.77	2.79	13.94	0.52	0.12
Sugar	December 11-26	5.42	94.58	2.12	----	---	88.0*	---	----	---	---
	February 6-19	6.12	93.88	1.76	----	----	88.0*	---	----	---	---
	April 2-19	4.88	95.12	1.34	----	----	88.0*	---	----	---	---
Palm oil	December 11-26	2.50	97.50	---	----	----	----	100.06	----	---	---
	February 6-19	2.04	97.96	---	----	---	----	99.91	----	---	---
	April 2-19	1.65	98.25	---	----	----	----	100.37	----	---	---

* This is not nitrogen-free extract but sugar by direct polarization calculated to dry matter. There were undoubtedly glucoses and sundry other bodies which would naturally be grouped under this heading. The nitrogen-free extract was assumed to be 90 per cent in the calculation of results of feeding.

(*b*) DIGESTION COEFFICIENTS *

	Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract
Hay	60	57	58	64	57
Silage	73	63	75	77	82
Mixed feed No. 1, †	71	83	42	76	82
" " " 2. †	78	84	58	82	79
" " " 3, †‡	71	80	31	76	82
" " " 4. †	76	74	24	84	78
Buckwheat middlings, ‡	75	80	33	81	86
Quaker dairy feed	62	81	43	67	89
Atlantic gluten feed	90	84	--	91	89
Sugar	--	--	--	100 §	--
Palm oil	--	--	--	---	80 §
Wheat bran	62	78	29	69	68
Corn meal	89	68	--	95	92
Cottonseed meal	74	88	56	61	93
Cleveland flax meal	79	85	80	86	97
Buffalo gluten feed	86	86	78	89	84

(*c*) POUNDS OF DIGESTIBLE NUTRIENTS IN ONE HUNDRED POUNDS OF ORIGINAL SUBSTANCE

Fodders and feeds	Dates ot sampling	Digestible nutrients				
		Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract
Hay	Nov. 13-29, Dec. 11-26	51.1	4.76	16.3	25.8	1.5
	Jan. 8 22, Feb. 5	49.9	5.70	13.4	26.3	1.7
	March 5-19, April 2-19	53.0	4.87	16.0	28.1	1.4
	April 30, May 14-21	54.0	5.50	15.3	28.2	1.8
Silage	Nov. 13-29, Dec. 26	19.7	1.58	4.7	11.8	0.8
	Jan. 8-22, Feb. 5	19.8	1.58	4.4	12.5	0.8
	March 19, April 2-19	20.2	1.57	4.8	12.4	0.8
	April 30, May 14	19.1	1.57	4.7	11.5	0.6
	December 11	16.0	1.49	3.7	9.5	0.6
	February 19	16.2	1.53	4.1	9.3	0.6
	March 5	15.3	1.57	4.1	7.8	0.6
Mixed feed No. 1 ¶	Nov. 23-29, Dec. 11-26	61.0	18.7	4.0	33.0	4.3
	Jan. 8-22. Feb. 5	61.2	18.9	4.1	32.7	4.5
	March 5-19, April 2-19	62.2	19.1	4.2	33.6	4.4
	April 30, May 14-21	61.8	19.2	4.1	33.0	4.4

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* From tables of digestibility of American feeding stuffs; Jordan and Hall, Bul. 81, Office Exp. Sta. (1900).

† Calculated from analyses of their ingredients and from digestion coefficients.

‡ No digestion experiments on buckwheat middlings have as yet been made; the coefficients of wheat middlings have been used in the absence of better figures.

§ Assumed.

¶ See footnote on next page.

DIGESTIBLE NUTRIENTS—Continued

Fodders and feeds	Dates of sampling	Digestible nutrients				
		Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract
Mixed feed No. 2	Nov. 13-29, Dec. 11-26	69.5	18.6	5.0	42.1	3.2
	Jan. 8-22, Feb. 5	69 6	18.1	5.1	42.6	3.2
	March 5-19, April 2-19	70.0	18.3	5.4	41.9	3.4
	April 30, May 14-21	69.2	18.3	5.2	41.5	3.2
Mixed feed No. 3	Nov. 13-29, Dec. 11-26	63.0	21.0	2.2	32.9	5.6
	Jan. 8-22, Feb. 5	63.4	21.2	2.6	32.3	5.7
	March 5-19, April 2-19	63.1	19.3	2.4	34.6	5.3
Mixed feed No. 4	Nov. 13-29, Dec. 11-26	67.4	9.4	1.7	50.7	3.7
	Jan. 8-22, Feb. 5	66.8	9.4	1.6	50.5	3.8
	March 5-19. April 2-19	66.6	9.1	1.6	50.9	3.6
	April 30, May 14-21	66.5	9.8	1.7	49.3	3.7
Corn meal	Nov. 13-29, Dec. 11-26	78.1	6.4	-- -	66.3	4.1
	Jan. 8-22, Feb. 5	76.7	6.7	-- -	64.6	4.1
	March 5-19, April 2-19	77.0	6.7	-- -	65.6	4.0
	April 30, May 14-21	76.7	6.7	-- -	64.6	4.1
Wheat bran	Nov. 13-29, Dec. 11-26	55.2	11.6	3.3	35.8	3.3
	Jan. 8-22, Feb. 5	55.2	11.8	3.5	34.9	3.4
	March 5-19, April 2-19	55.6	12.2	3.4	35.7	3.5
	April 30, May 14-21	55.2	12.1	3.3	34.9	3.4
Cottonseed meal	Nov. 13-29, Dec. 11-26	67.0	40.4	3 0	14.9	8.1
	Jan. 8-22, Feb. 5 19	67.6	41.0	2.7	15.2	7.7
	March 5-19, April 2-19	67.4	41.6	2.7	14.7	7.9
	April 30, May 14-21	66.7	40.7	2.8	14.9	7.6
Cleveland flax meal	Nov. 13-29, Dec. 11-26	69.9	29.8	8.1	29.6	3.9
	Jan. 8-22, Feb. 5-19	69.6	30.3	7.7	29.3	4.0
	March 5-19, April 2-19	69.8	30.2	7.9	29.3	4.1
	April 30, May 14-21	70.2	29.8	8.1	29.4	4.1
Buffalo gluten feed	Nov. 13-29, Dec. 11-26	79.2	22.5	5.8	47.5	2.8
	Jan. 8-22, Feb. 5-19	78.7	22.2	5.8	47.1	3.1
	March 5-19, April 2-19	78.9	23.4	5.9	45.8	3.0
	April 30. May 14-21	78.6	22.8	6.1	45.6	3.4
Buckwheat middlings	Nov. 13-29, Dec. 11-26	67.5	26.0	1.6	32.7	7.2
	Dec. 8-22, Feb. 5-19	67.4	25.6	1.6	32.7	7.1
	March 5-19, April 2-19	67.2	22 6	1.8	36.0	6.2
Quaker dairy feed	December 26	56.9	10.0	8.8	34.5	2.6
	Jan. 8-22, Feb. 5-19	57.3	10.6	7.9	35.7	2.8
	March 5-19, April 2-19	57.2	9.7	8.1	36.2	2.7
	April 30, May 14-21	56.9	10.0	8.4	35.3	2.7
Atlantic gluten flour	December 26	82.9	68.8	-- -	7.0	1.3
	Jan 8-22, Feb. 5-19	83.0	68.7	-- -	7.3	1.3
	March 5-19, April 2-19	82.8	68.0	-- -	7.2	1.8
	April 30, May 14-21	83.1	67.6	-- -	7.4	2.3
Sugar	December 26	94.0	-- -	-- -	90.0†	- -
Palm oil	December 26	78.4	-- -	-- -	-- -	78.4†

* The figures actually used in calculating the digestible nutrients eaten differed from these very slightly, in no case exceeding them more than 1 pound of dry matter, 0.7 of a pound of protein or 0.8 of a pound of nitrogen-free extract. A contingency peculiar to this particular set of trials rendered the figures as shown in the tables slightly inaccurate. The data actually used was determined with great care and are thought to be more nearly representative of the facts than the figures in the tables.

† Assumed.

IV. FEEDING RECORDS OF INDIVIDUAL COWS

Name of cow	Low, medium and high grain feeding Period numbers	Nature of ration	Pounds eaten of: Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period: Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	Nutritive ratio, 1:
BEAUTINA	I. Preliminary	No. 1 Low	133	354	11	31	21	258.4	54.4	177.2	23.3	40.7	98.7	7.5	6.7
	Experimental	"	213	647	9	36	27	422.9	61.3	280.8	34.3	68.1	155.6	11.5	7.3
	II. Preliminary	Medium	120	364	9	38	29	244.6	65.0	166.6	25.8	36.0	91.2	7.2	5.6
	Experimental	"	214	648	18	72	54	471.9	124.0	326.2	48.2	71.2	180.3	14.6	5.9
	III. Preliminary	High	119	357	14	55	41	292.3	95.5	198.4	33.9	36.0	112.6	9.7	5.0
	Experimental	"	214	641	27	106	80	526.6	186.2	381.7	63.9	65.4	207.3	18.2	4.9
	IV. Preliminary	Medium	117	358	10	42	32	254.3	71.7	181.5	28.7	34.8	103.5	8.5	5.5
	Experimental	"	212	648	18	72	54	464.3	123.1	311.8	50.1	61.5	174.3	14.6	5.4
	V. Preliminary	Low	119	360	5	20	15	226.0	34.9	152.3	19.4	36.6	83.4	6.1	6.9
	Experimental	"	215	648	9	36	27	420.5	61.6	289.9	34.9	68.3	165.2	11.4	7.4
	VI. Preliminary	Medium	119	360	10	38	29	273.3	68.1	184.1	26.7	39.3	104.3	8.0	6.1
	Experimental	"	213	648	18	72	54	495.4	128.6	334.1	49.1	70.8	189.2	14.6	6.0
	VII. Preliminary	High	114	359	13	53	39	294.2	92.3	195.6	32.6	38.4	108.5	8.9	5.1
	Experimental	"	262	412	27	108	81	516.7	187.3	355.0	63.5	67.8	193.4	16.9	4.7
DAHLIA	I. Preliminary	No. 1 Low	109	357	10	30	21	237.5	52.6	164.3	21.8	36.9	92.2	7.1	6.7
	Experimental	"	208	632	8	34	25	410.2	57.6	272.3	32.8	66.4	150.9	11.0	7.4
	II. Preliminary	Medium	111	349	8	35	26	227.8	59.0	155.3	23.8	33.7	85.1	6.7	5.6
	Experimental	"	196	642	17	69	52	449.5	118.8	312.2	46.1	67.7	173.0	14.1	5.9
	III. Preliminary	High	97	344	11	47	35	255.0	80.8	174.3	29.1	31.9	99.5	8.5	5.2
	Experimental	"	177	614	20	83	62	447.0	144.2	312.4	52.0	57.4	178.2	15.2	5.2
	IV. Preliminary	Medium	96	351	9	35	26	223.2	59.8	160.9	24.7	31.1	92.4	7.5	5.7
	Experimental	"	159	645	16	64	46	401.9	107.7	273.4	43.5	53.6	154.1	12.8	5.4
	V. Preliminary	High	93	360	10	43	32	242.4	74.1	166.7	27.0	34.3	91.4	7.7	5.3
	Experimental	"	167	538	20	83	62	429.0	141.1	300.7	49.3	59.0	169.7	14.0	5.3
	VI. Preliminary	Medium	90	296	9	37	27	226.3	64.6	153.3	23.3	31.5	86.8	6.9	5.7
	Experimental	"	165	538	16	66	49	410.7	117.0	278.2	42.4	57.4	157.6	12.5	5.7
	VII. Preliminary	"	85	300	9	35	27	221.7	62.4	147.5	23.4	29.8	82.2	6.5	5.4
	Experimental	"	206	372	18	71	53	393.4	123.1	270.8	45.2	54.5	148.3	12.4	5.1
ACME	II. Preliminary	No. 1 Medium	115	232	10	37	29	211.5	65.0	143.0	23.6	30.3	77.4	6.4	5.2
	Experimental	"	204	523	18	71	54	431.3	123.1	295.9	45.6	63.6	162.7	13.5	5.6
	III. Preliminary	High	103	277	13	54	40	255.0	93.0	172.6	31.1	30.2	97.3	8.7	4.7
	Experimental	"	179	522	27	107	81	468.9	187.9	342.0	60.4	55.5	183.9	16.7	4.6
	IV Preliminary	Medium	118	297	11	42	31	240.5	71.7	169.9	27.8	32.3	96.1	8.1	5.3
	Experimental	"	206	531	18	72	54	430.9	123.1	287.8	47.9	55.7	160.0	13.7	5.6
	V. Preliminary	Low	115	295	5	20	15	206.8	34.9	138.5	18.2	33.1	75.7	5.5	6.7
	Experimental	"	207	528	9	36	27	381.8	61.6	261.4	32.6	61.2	148.1	10.3	7.1
	VI. Preliminary	Medium	111	232	10	38	29	230.5	68.1	154.0	24.3	31.0	86.1	6.9	5.5
	Experimental	"	210	422	18	72	54	432.3	128.6	286.8	45.4	59.5	160.3	12.8	5.5
	VII. Preliminary	High	106	230	13	52	39	251.2	91.4	166.0	29.9	31.1	91.0	8.0	4.7
	Experimental	"	248	307	27	108	81	479.6	187.3	327.3	61.0	60.8	174.4	16.0	4.4
NANCY B	II. Preliminary	No. 1 Medium	153	350	10	42	31	274.9	70.9	185.7	28.5	41.1	100.8	7.9	5.6
	Experimental	"	272	636	18	72	54	519.7	124.0	353.6	50.8	80.0	193.9	15.4	6.1
	III. Preliminary	Low	153	359	5	20	15	261.8	34.8	172.2	22.2	38.0	98.4	7.2	6.9
	Experimental	"	285	635	9	36	27	460.6	62.9	312.6	40.3	69.1	178.3	13.0	6.9
	IV. Preliminary	Medium	159	353	9	37	28	279.4	63.2	195.1	29.1	43.7	110.6	8.8	6.0
	Experimental	"	274	646	18	72	54	518.0	123.1	342.4	53.6	69.7	190.4	15.6	5.5
	V. Preliminary	Low	153	358	5	20	15	255.3	34.9	169.9	21.0	42.0	92.8	6.5	7.1
	Experimental	"	276	646	9	36	27	473.3	61.6	321.9	37.8	77.9	182.1	12.2	7.6
	VI. Preliminary	Medium	154	340	10	40	30	301.2	70.8	200.5	28.7	44.1	112.6	8.4	6.1
	Experimental	"	274	630	18	72	54	546.1	128.6	362.8	51.7	79.7	204.1	15.3	6.2
	VII. Preliminary	High	148	348	10	42	30	304.3	73.8	198.8	30.2	42.2	109.8	8.6	5.7
	Experimental	"	284	404	27	108	81	534.3	187.3	365.3	64.5	70.8	198.7	17.2	4.8

Name of cow	Low, medium and high grain feeding	Nature of ration	Pounds eaten of				Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period					Nutritive ratio, 1:
	Period numbers		Hay	Silage	Wheat bran	Buffalo gluten feed*			Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	
ROSEMARY		No. 1												
	I. Preliminary	Low	115	234	14	28	201.9	44.6	139.5	17.7	32.1	79.0	5.2	6.9
	Experimental	"	207	427	24	47	359.1	63.6	239.2	29.8	57.5	133.7	8.7	7.1
	II. Preliminary	Medium	118	240	25	51	218.3	67.6	145.9	24.0	57.7	78.8	6.6	6.3
	Experimental	"	211	432	48	96	419.1	127.4	293.0	43.6	62.0	166.0	11.2	5.8
	III. Preliminary	High	114	233	34	69	252.4	92.2	174.7	28.8	30.8	103.0	7.0	5.2
	Experimental	"	178	427	63	126	423.0	166.9	304.8	51.1	52.4	180.7	12.4	5.1
	IV. Preliminary	Medium	116	238	25	51	221.6	68.6	157.9	24.1	30.0	92.6	6.3	5.7
	Experimental	"	211	428	44	89	405.7	118.4	274.9	42.7	53.2	158.9	10.8	5.5
	V. Preliminary	Low	116	239	13	25	193.5	34.2	120.6	16.4	31.2	72.7	4.6	7.0
	Experimental	"	211	432	24	47	361.7	63.3	248.8	30.0	58.2	142.6	8.8	7.4
	VI. Preliminary	Medium	111	231	21	42	219.1	57.0	148.9	20.4	32.2	85.8	5.5	6.4
	Experimental	"	196	430	43	85	407.4	114.3	280.4	39.7	58.8	162.0	10.5	6.2
	VII. Preliminary	High	110	231	21	43	219.9	56.1	147.8	21.4	31.0	84.1	5.5	6.0
	Experimental	"	246	294	62	125	454.0	166.6	313.8	52.4	61.2	180.8	12.3	5.1
EULALIE		No. 2												
	I. Preliminary	Low	...	...	..	...	...	...	...	...	...	...	...	..
	Experimental	"	281	644	24	48	483.4	64.5	320.4	36.9	79.9	178.8	11.6	7.7
	II. Preliminary	Medium	158	354	25	51	276.7	67.6	190.1	26.9	42.6	106.4	6.8	6.1
	Experimental	"	282	647	48	96	534.5	127.4	371.6	50.4	83.8	209.7	13.9	6.4
	III. Preliminary	High	158	360	39	78	336.3	104.7	231.5	35.9	43.1	136.4	9.2	5.6
	Experimental	"	287	643	72	144	592.2	190.7	420.8	65.0	78.0	247.9	16.8	5.5
	IV. Preliminary	Very high	159	358	47	95	345.6	128.2	249.0	40.4	44.4	147.1	10.0	5.3
	Experimental	"	276	648	96	191	652.5	255.4	454.1	77.6	79.1	265.5	18.4	5.0
	V. Preliminary	High	158	360	40	80	333.3	108.0	231.8	35.3	47.7	131.0	8.9	5.6
	Experimental	"	282	648	72	144	610.1	192.7	431.5	63.4	87.8	250.1	16.4	5.9
	VI. Preliminary	Medium	157	359	27	53	310.7	72.3	211.7	27.9	46.6	122.2	7.8	6.7
	Experimental	"	278	647	48	96	554.2	128.6	378.8	50.1	83.2	218.7	13.9	6.7
	VII. Preliminary	Low	151	360	26	51	303.9	67.5	203.6	28.1	44.0	115.9	7.5	6.3
	Experimental	"	304	425	24	48	443.9	74.2	295.1	36.6	70.2	164.5	10.5	7.1
POMONA		No. 2												
	III. Preliminary	High	105	289	37	75	267.1	100.2	187.5	30.8	32.6	111.4	7.6	5.2
	Experimental	"	198	494	68	136	469.8	180.1	338.6	56.0	58.8	200.7	13.7	5.2
	IV. Preliminary	Medium	117	293	28	55	242.0	74.9	174.2	26.3	32.9	102.8	6.9	5.8
	Experimental	"	194	540	48	96	427.6	128.2	294.2	45.4	56.2	171.2	11.6	5.6
	V. Preliminary	Low	116	299	13	27	209.8	36.0	142.7	17.7	34.0	799.6	5.1	7.1
	Experimental	"	209	540	24	48	389.3	64.2	270.3	31.8	63.1	155.9	9.6	7.6
	VI. Preliminary	Medium	111	290	26	54	250.8	72.3	173.4	24.6	35.9	100.7	6.5	6.1
	Experimental	"	202	531	48	96	454.1	128.6	315.1	44.5	65.5	182.9	11.9	6.2
	VII. Preliminary	High	104	278	32	65	256.0	85.1	176.3	27.8	34.0	101.6	6.7	5.4
	Experimental	"	255	325	72	144	495.2	192.5	349.3	58.7	65.5	198.9	13.6	5.0
INEZ		No. 2												
	I. Preliminary	Medium	...	...	..	...	...	...	...	...	...	...	...	..
	Experimental	"	207	407	50	100	423.4	133.3	280.5	47.8	56.3	150.9	14.7	5.0
	II. Preliminary	"	119	200	28	56	217.3	74.4	145.7	26.3	28.6	77.1	7.6	4.7
	Experimental	"	211	360	48	95	400.6	126.8	275.2	52.8	53.7	143.5	16.3	4.4
	III. Preliminary	Low	119	200	13	27	191.6	35.7	124.4	18.5	25.8	69.2	5.9	5.9
	Experimental	"	216	360	24	48	334.9	64.4	224.7	33.3	46.8	125.1	10.6	5.9
	IV. Preliminary	Medium	120	250	25	49	225.5	66.2	156.3	26.6	29.1	86.7	8.2	5.0
	Experimental	"	213	540	48	95	443.4	127.4	294.2	50.9	55.2	161.1	15.5	4.9
	V. Preliminary	High	119	298	26	51	244.4	68.3	224.7	25.3	34.1	91.1	7.9	5.7
	Experimental	"	212	540	58	116	481.7	154.0	331.2	52.4	63.9	186.7	16.5	5.5
	VI. Preliminary	Medium	117	299	26	51	254.9	68.5	171.0	25.3	34.9	96.6	8.1	5.9
	Experimental	"	209	540	46	92	457.4	123.2	307.2	44.9	62.5	174.1	14.4	6.0

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* This column for the cow Rosemary represents ½ cottonseed and ½ linseed meals **instead of Buffalo gluten** feed.

Name of cow	Low, medium and high grain feeding	Nature of ration	Pounds eaten of				Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period					Nutritive ratio, 1:
	Period numbers		Hay	Silage	Wheat bran	Buckwheat middlings			Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	
STAR BRIGHT	I. Preliminary	No. 3 Low	95	294	12	23	187.7	31.1	128.5	16.5	30.2	70.7	5.7	6.9
	Experimental	"	176	537	24	47	362.0	63.1	240.4	31.8	55.7	132.1	10.8	6.7
	II. Preliminary	Medium	99	299	25	51	215.2	67.3	146.3	25.1	28.8	78.9	7.4	5.0
	Experimental	"	176	540	48	96	415.6	127.7	293.5	54.2	56.5	156.1	17.3	4.6
	III. Preliminary	High	95	296	38	77	262.5	102.5	178.9	34.6	28.8	99.1	10.5	5.0
	Experimental	"	175	533	72	144	473.8	193.3	329.7	64.4	52.7	182.4	19.4	4.3
	IV. Preliminary	Medium	98	299	28	55	226.9	74.2	160.7	28.0	28.5	90.0	8.7	4.9
	Experimental	"	176	540	48	95	411.1	127.4	275.7	48.8	50.2	151.3	14.9	4.8
	V. Preliminary	Low	97	330	13	27	200.0	35.5	135.3	17.6	31.1	74.4	5.9	6.8
	Experimental	"	176	644	24	48	387.5	63.7	268.8	32.6	60.7	154.2	11.4	7.7
	VI. Preliminary	Medium	94	357	26	51	250.9	68.5	170.5	25.0	34.0	97.3	8.2	6.0
	Experimental	"	167	642	45	89	446.5	123.2	305.5	44.4	60.7	174.9	14.7	6.1
RACHEL	II. Preliminary	No. 3 Medium	117	199	25	49	206.5	65.5	138.5	23.5	28.0	74.3	6.9	5.0
	Experimental	"	203	360	48	96	394.5	127.7	271.8	52.7	52.4	141.8	16.3	4.4
	III. Preliminary	High	116	200	38	77	255.8	102.5	170.4	34.3	27.4	92.7	10.1	4.2
	Experimental	"	214	359	68	135	450.4	181.7	306.6	61.1	49.9	166.7	18.0	4.2
	IV. Preliminary	Medium	119	199	28	56	221.3	75.1	152.1	27.8	26.9	83.3	8.4	4.6
	Experimental	"	212	520	48	96	438.7	128.3	290.7	50.7	54.2	158.9	15.4	4.9
	V. Preliminary	Low	118	299	13	27	211.0	35.5	140.9	18.2	33.1	77.2	5.9	6.8
	Experimental	"	214	540	24	48	393.2	63.7	267.9	32.8	61.8	152.0	11.1	7.3
	VI. Preliminary	Medium	117	285	26	53	252.8	70.3	169.4	25.4	34.2	95.6	8.1	5.8
	Experimental	"	202	537	47	94	452.9	125.8	304.6	45.1	61.3	172.8	14.5	5.9
PUSSY WILLOW	III. Preliminary	No. 3 Medium	...	...	..	..	....	....	....	..	..	....	..	..
	Experimental	"	177	526	38	77	383.4	102.9	265.3	42.9	50.0	149.5	13.6	5.4
	IV. Preliminary	"	114	299	27	53	237.5	71.3	166.8	28.3	30.6	93.2	8.8	5.1
	Experimental	"	203	539	48	96	435.4	128.3	289.6	50.5	53.8	158.7	15.4	4.9
	V. Preliminary	Low	120	300	13	27	213.2	35.5	142.2	18.3	33.5	77.9	6.0	6.9
	Experimental	"	211	537	24	48	389.8	63.7	265.7	32.6	61.2	150.8	11.0	7.3
	VI. Preliminary	Medium	111	294	23	46	241.1	61.4	161.7	23.3	33.5	91.5	7.5	6.1
	Experimental	"	203	535	46	91	449.8	122.3	302.3	44.3	61.3	171.4	14.3	6.0

Name of cow	Adding single nutrients	Nature of ration	Pounds eaten of								Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period					Nutritive ratio, 1:
	Period numbers		Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Atlantic gluten flour	Sugar	Palm oil			Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	
CERES	I. Pre.	No. 1	118	360	13	40	27	- --	- --	- --	262.2	69.0	181.2	26.0	39.2	101.3	8.1	6.1
	Exp.	"	211	647	18	72	54	- --	- --	- --	483.0	123.8	324.5	48.1	70.6	179.5	14.6	5.9
	II. Pre.	oil	119	360	10	40	30	- --	- --	3.3	249.5	71.6	170.5	26.5	35.8	91.9	9.9	5.7
	Exp.	"	207	644	17	69	51	- --	- --	12.8	471.2	130.4	327.5	46.5	69.5	175.7	24.2	6.4
	III. Pre.	No. 1	118	359	10	40	30	- --	- --	- --	266.0	69.6	179.7	28.0	34.8	102.5	8.4	5.6
	Exp.	"	215	648	18	72	54	- --	- --	- --	468.8	125.9	325.0	50.6	63.1	185.5	15.1	5.6
	IV. Pre.	glu.	110	360	10	40	30	7.5	- --	- --	259.9	75.2	186.6	33.2	35.0	103.5	8.5	4.7
	Exp.	"	212	648	18	72	54	18.	- --	- --	480.9	139.7	326.7	62.4	61.5	175.6	14.8	4.3
	V. Pre.	No. 1	119	360	10	40	30	- --	- --	- --	260.9	69.8	177.4	27.3	38.2	97.0	7.9	5.6
	Exp.	"	214	646	18	72	54	- --	- --	- --	480.6	123.1	334.2	49.1	70.9	189.2	14.6	6.0
	VI Pre.	sugar	117	354	10	40	30	- --	27.	- --	298.3	96.6	209.1	27.1	38.8	128.3	8.0	6.8
	Exp	"	205	640	18	72	54	- --	54.	- --	537.0	179.7	379.0	48.5	69.2	234.5	14.4	6.9
	VII. Pre.	No. 1	107	360	10	40	30	- --	2.	- --	267.9	72.2	178.5	27.3	36.4	10 .1	7.7	5.6
	Exp.	"	246	417	18	72	54	- --	- --	- --	441.1	124.8	302.3	48.5	62.8	165.4	13.4	5.3
COWSLIP	I. Pre.	No. 1	118	270	11	38	26	- --	- --	- --	233.9	64.6	160.3	23.9	34.8	88.5	7.2	5.8
	Exp.	"	166	534	17	66	50	- --	- --	- --	403.8	114.3	272.5	42.0	57.5	150.8	12.5	5.6
	II. Pre.	glu.	96	298	10	39	30	2.	- --	- --	214.5	69.3	147.3	25.6	29.7	79.9	6.6	4.9
	Exp.	"	163	537	17	69	51	17.	- --	- --	409.4	133.7	288.1	54.4	57.3	152.9	12.9	4.4
	III. Pre.	No. 1	105	299	10	38	30	- --	- --	- --	237.2	67.7	160.0	25.9	30.4	91.0	7.6	5.3
	Exp.	"	172	534	17	67	51	- --	- --	- --	396.3	118.0	275.3	44.6	52.0	156.9	13.1	5.3
	IV. Pre.	sugar	97	296	10	38	21	- --	23.	- --	238.6	87.4	176.4	25.2	29.1	108.9	7.4	6.1
	Exp.	"	157	537	17	69	52	- --	52.	- --	433.2	166.8	309.6	44.1	49.2	192.6	12.6	6.1
	V. Pre.	No. 1	80	299	8	34	25	- --	- --	- --	200.6	58.4	137.6	21.9	28.8	75.5	6.3	5.4
	Exp.	"	153	533	16	63	47	- --	- --	- --	382.1	107.7	267.8	40.8	55.0	151.9	12.0	5.7
	VI. Pre.	oil	92	237	5	22	16	- --	- --	3.5	188.7	41.6	126.3	16.7	27.7	69.9	7.8	6.9
	Exp.	"	166	357	14	57	43	- --	- --	10.5	358.2	111.9	239.8	36.3	48.2	129.6	18.5	6.0
	VII. Pre.	No. 1	93	200	9	37	28	- --	- --	- --	204.8	65.0	134.6	22.8	26.5	73.9	6.2	5.0
	Exp.	"	215	270	17	70	52	- --	- --	- --	374.8	120.5	254.4	43.5	51.0	138.1	11.8	5.0
HAIDEE	II. Pre.	glu.	100	298	10	40	30	2.	- --	- --	218.9	70.3	150.0	26.0	30.4	81.3	6.7	4.9
	Exp.	"	174	530	18	72	54	18.	- --	- --	424.2	140.6	297.5	56.8	59.1	157.4	13.3	4.3
	III. Pre.	No. 1	100	300	10	40	30	- --	- --	- --	235.1	69.6	159.0	26.0	29.8	90.4	7.6	5.3
	Exp.	"	179	539	18	72	54	- --	- --	- --	411.3	125.9	285.4	46.8	53.5	162.4	13.7	5.3
	IV. Pre.	sugar	99	299	10	40	30	- --	24.	- --	244.3	90.8	180.9	26.0	29.6	111.7	7.6	6.1
	Exp.	"	178	540	18	72	54	- --	54.	- --	459.2	173.8	326.2	46.5	52.4	202.2	13.2	6.1
	V. Pre.	No. 1	98	321	10	40	30	- --	- --	- --	233.1	69.8	159.2	25.7	33.1	87.2	7.3	5.3
	Exp.	"	169	645	18	72	54	- --	- --	- --	441.0	123.1	310.2	46.9	63.6	176.4	13.9	5.8
	VI. Pre.	oil	93	350	7	31	22	- --	- --	5	237.5	58.0	161.5	21.9	34.0	89.9	10.7	6.8
	Exp.	"	170	638	15	58	44	- --	- --	10.5	439.6	114.6	300.5	41.5	62.4	166.7	20.9	6.7
	VII. Pre.	No. 1	95	359	10	39	30	- --	- --	- --	253.7	69.4	169.2	26.4	34.5	94.5	7.5	5.5
	Exp.	"	220	399	18	72	54	- --	- --	- --	413.8	124.8	284.9	46.8	58.0	156.0	12.9	5.2

Name of cow	Adding single nutrients	Nature of ration	Pounds eaten of								Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period					Nutritive ratio, 1 :
	Period numbers		Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Atlantic gluten flour	Sugar	Palm oil			Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	
LADYSMITH	I. Pre.	No. 1	114	349	12	35	23	- - -	- - -	- - -	247.3	60.4	170.7	23.7	37.7	95.5	7.5	6.3
	Exp.	"	203	564	14	57	42	- - -	- - -	- - -	426.7	97.1	284.9	40.4	64.2	157.1	12.5	6.2
	II. Pre.	sugar	116	291	10	38	29	- - -	28.5	- - -	253.2	92.9	180.3	24.7	32.7	109.3	6.8	6.4
	Exp.	"	199	538	18	70	53	- - -	54.	- - -	479.9	172.4	345.9	45.2	63.4	211.1	13.6	6.8
	III. Pre.	No. 1	117	298	10	38	29	- - -	- - -	- - -	246.6	66.9	165.2	26.4	31.9	93.7	8.6	5.5
	Exp.	"	215	533	18	69	53	- - -	- - -	- - -	436.0	122.3	299.7	48.0	57.9	169.8	14.1	5.4
	IV. Pre.	oil	118	290	7	26	20	- - -	- - -	4.	216.3	49.1	152.3	21.6	30.7	84.9	9.8	6.4
	Exp.	"	204	539	15	62	46	- - -	- - -	11.	423.9	116.0	283.8	43.9	55.0	153.4	21.4	5.8
	V. Pre.	No. 1	116	299	10	39	30	- - -	- - -	- - -	242.7	68.9	164.2	26.0	35.0	89.7	7.3	5.4
	Exp.	"	210	539	18	71	54	- - -	- - -	- - -	448.0	122.3	309.9	47.0	65.1	174.5	13.6	5.7
	VI. Pre.	glu.	113	299	10	37	28	8.	- - -	- - -	256.8	73.9	173.9	30.5	35.4	94.9	7.5	4.8
	Exp.	"	195	528	14	57	43	14.	- - -	- - -	433.0	114.7	293.0	49.9	61.0	160.0	12.3	5.0
	VII. Pre.	No. 1	112	300	9	37	28	2.	- - -	- - -	251.1	66.8	165.7	26.8	34.1	91.0	7.2	5.3
	Exp.	"	226	330	18	71	53	- - -	- - -	- - -	401.2	123.1	273.6	45.6	55.6	149.1	12.5	5.1
NAOMI	III. Pre.	No. 1	96	353	10	40	30	- - -	- - -	- - -	245.4	69.6	167.5	26.7	31.6	96.0	7.9	5.4
	Exp.	"	175	643	18	72	54	- - -	- - -	- - -	434.4	125.9	304.0	48.2	57.6	174.3	14.4	5.5
	IV. Pre.	oil	99	357	10	40	30	- - -	- - -	6.	241.4	74.0	174.5	26.9	32.2	97.3	12.7	5.9
	Exp.	"	171	608	16	66	49	- - -	- - -	12.	419.5	123.8	285.5	44.6	53.8	154.9	22.4	5.8
	V. Pre.	No. 1	95	360	10	40	30	- - -	- - -	- - -	239.9	69.8	164.5	26.1	34.4	90.3	7.5	5.4
	Exp.	"	164	643	18	72	54	- - -	- - -	- - -	436.1	123.1	307.1	46.6	64.5	174.8	13.9	5.8
	VI. Pre.	glu.	93	350	10	40	30	8.5	- - -	- - -	258.2	78.7	177.2	31.6	34.8	97.3	7.8	4.7
	Exp.	"	165	626	18	71	54	18.	- - -	- - -	461.5	144.3	318.4	58.4	62.0	173.9	14.0	4.6
	VII. Pre.	No. 1	94	330	10	40	30	2.	- - -	- - -	229.4	72.2	154.5	26.4	29.9	85.7	7.0	5.0
	Exp.	"	225	418	18	72	54	- - -	- - -	- - -	422.8	124.8	291.2	47.3	59.6	159.6	13.1	5.3
PAULINE	II. Pre.	sugar	- - -	- - -	- -	- -	- -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- -
	Exp	"	177	613	17	66	51	- - -	50.	- - -	469.4	162.6	341.2	44.0	63.1	208.3	13.4	6.9
	III. Pre.	No. 1	96	358	10	40	30	- - -	- - -	- - -	246.7	69.6	168.5	26.7	31.8	96.6	8.0	5.5
	Exp.	"	178	638	18	72	54	- - -	- - -	- - -	435.6	125.9	304.5	48.3	57.7	174.5	14.4	5.5
	IV. Pre.	oil	99	359	10	40	30	- - -	- - -	6.	241.9	74.0	174.9	26.9	32.3	97.5	12.7	5.9
	Exp.	"	175	647	18	72	54	- - -	- - -	13.5	445.0	136.4	303.8	48.0	56.5	164.5	24.5	5.8
	V. Pre.	No. 1	97	360	10	40	30	- - -	- - -	- - -	241.6	69.8	165.6	26.2	34.7	90.8	7.6	5.4
	Exp.	"	168	648	18	72	54	- - -	- - -	- - -	440.9	123.1	310.2	46.9	63.6	176.5	14.0	5.8
	VI. Pre.	glu.	94	353	10	40	30	8.5	- - -	- - -	259.9	78.7	178.3	31.7	35.1	98.0	7.9	4.8
	Exp.	"	170	406	18	69	52	17.3	- - -	- - -	403.1	140.0	273.5	53.9	52.2	146.6	12.2	4.2
	VII. Pre.	No. 1	96	200	10	40	30	- - -	- - -	- - -	212.9	70.3	139.9	24.2	27.2	76.8	6.5	4.9
	Exp.	"	259	274	18	72	54	- - -	- - -	- - -	419.0	124.8	282.0	46.9	58.1	152.7	12.8	5.1

Name of cow	Adding single nutrients	Nature of ration	Pounds eaten of								Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period					Nutritive ratio, 1 :
	Period numbers		Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Atlantic gluten flour	Sugar	Palm oil			Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	
PRETORIA	I. Pre.	No. 1	114	294	13	38	26	- - -	- - -	- - -	234.5	62.1	161.2	23.2	35.1	89.8	7.1	6.1
	Exp.	"	214	442	13	54	41	- - -	- - -	- - -	398.5	92.8	263.4	38.0	0.0	143.9	11.5	6.0
	II. Pre.	oil	119	200	8	34	25	- - -	- - -	2.3	202.3	59.4	142.1	21.6	29.4	72.1	7.6	5.5
	Exp.	"	208	359	15	61	46	- - -	- - -	11.5	387.2	116.2	261.6	39.1	55.6	137.3	20.3	6.1
	III. Pre.	No. 1	120	200	10	40	30	- - -	- - -	- - -	226.4	69.6	149.2	25.6	28.1	83.2	7.2	5.0
	Exp.	"	214	258	17	68	52	- - -	- - -	- - -	388.2	119.7	262.8	44.6	49.9	146.7	12.6	5.0
	IV. Pre.	glu.	119	200	10	38	29	7.3	- - -	- - -	219.0	72.5	152.8	30.0	27.8	82.5	7.1	4.2
	Exp.	"	211	360	18	71	53	18.	- - -	- - -	408.9	137.9	273.2	57.6	49.1	143.3	12.7	3.8
	V. Pre.	No. 1	118	197	10	40	30	- - -	- - -	- - -	220.7	69.8	147.8	24.7	30.8	80.3	6.7	5.1
	Exp.	"	211	360	18	71	53	- - -	- - -	- - -	400.8	121.4	273.5	44.0	56.7	152.2	12.2	5.4
	VI. Pre.	sugar	112	199	9	37	28	- - -	25.	- - -	243.5	89.4	169.4	23.2	30.4	103.8	6.5	6.4
	Exp.	"	203	360	18	70	52	- - -	53.	- - -	455.9	175.2	317.9	43.3	55.3	197.0	12.0	6.5
	VII. Pre.	No. 1	117	200	10	38	29	- - -	- - -	- - -	229.7	67.7	149.4	24.8	30.3	81.7	6.8	5.1
	Exp.	"	255	280	18	70	53	- - -	- - -	- - -	414.3	122.2	279.2	46.2	57.6	151.2	12.6	5.1
PRISCILLA	I. Pre.	No. 1	- - -	- - -	- -	- -	- -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- -
	Exp.	"	197	511	18	72	54	- - -	- - -	- - -	433.8	123.6	290.6	45.2	61.9	159.8	13.3	5.6
	II. Pre.	glu.	116	299	10	40	30	2.	- - -	- - -	232.4	70.3	158.4	26.8	33.1	85.5	7.0	5.0
	Exp.	"	202	536	18	72	54	18.	- - -	- - -	450.2	140.6	313.0	58.3	63.9	165.3	13.8	4.5
	III. Pre.	No. 1	112	296	0	40	30	- - -	- - -	- - -	244.4	69.6	164.2	26.7	31.2	93.1	7.8	5.3
	Exp.	"	212	534	18	72	54	- - -	- - -	- - -	437.4	125.9	300.9	48.6	57.7	170.5	14.2	5.4
	IV. Pre.	sugar	117	299	10	39	30	- - -	24.	- - -	258.5	90.0	168.9	26.8	32.0	116.1	7.8	6.2
	Exp.	"	202	537	18	72	54	- - -	54.	- - -	479.5	173.8	347.7	47.8	55.5	208.2	13.6	6.2
	V. Pre.	No. 1	117	291	10	40	30	- - -	- - -	- - -	243.3	69.8	164.5	26.1	35.0	89.8	7.4	5.4
	Exp.	"	202	534	18	72	54	- - -	- - -	- - -	440.5	123.1	305.2	46.7	63.6	171.9	13.5	5.7
	VI. Pre.	oil	109	240	5	18	14	- - -	- - -	3.3	198.8	35.9	132.0	16.4	30.4	73.0	7.6	7.3
	Exp.	"	191	425	14	58	44	- - -	- - -	10.5	400.9	113.7	267.9	38.9	55.5	145.8	19.5	6.3
	VII. Pre.	No. 1	104	239	10	39	30	- - -	- - -	- - -	229.8	69.4	151.0	25.0	30.2	83.2	6.9	5.2
	Exp.	"	256	300	18	72	54	- - -	- - -	- - -	422.6	124.8	285.4	47.2	58.9	154.8	12.9	5.1
RUTH	I. Pre.	No. 1	99	360	13	40	27	- - -	- - -	- - -	246.4	69.0	171.5	25.1	36.1	96.4	7.8	6.0
	Exp.	"	177	645	18	72	54	- - -	- - -	- - -	453.2	123.8	306.7	46.4	65.0	170.4	14.1	5.8
	II. Pre.	oil	100	349	9	35	27	- - -	- - -	2.3	222.5	62.8	152.7	23.7	32.0	83.0	8.4	5.7
	Exp.	"	176	617	17	68	52	- - -	- - -	13.	437.6	130.6	306.5	44.6	63.2	164.5	23.7	6.3
	III. Pre.	No. 1	98	355	10	40	30	- - -	- - -	- - -	247.6	69.6	168.9	26.8	32.0	96.8	8.0	5.5
	Exp.	"	179	585	18	72	54	- - -	- - -	- - -	422.9	125.9	294.5	47.5	55.5	168.2	14.0	5.4
	IV. Pre.	glu.	99	352	10	40	30	7.5	- - -	- - -	241.4	75.2	175.0	32.0	32.0	97.2	8.1	4.6
	Exp.	"	173	633	18	71	54	18.	- - -	- - -	442.3	138.7	303.9	59.8	55.6	163.4	14.0	4.2
	V. Pre.	No. 1	98	345	10	40	30	- - -	- - -	- - -	238.8	69.8	163.5	26.0	34.2	89.6	7.5	5.4
	Exp.	"	175	583	18	72	54	- - -	- - -	- - -	429.9	123.1	300.8	46.2	61.6	170.4	13.5	5.7
	VI. Pre.	sugar	93	234	10	40	30	- - -	27.	- - -	243.7	96.6	172.2	24.0	29.3	106.7	6.8	6.3
	Exp.	"	178	343	18	70	54	- - -	54.	- - -	431.3	177.9	303.4	42.2	50.6	189.4	11.6	6.3
	VII. Pre.	No. 1	96	191	10	40	30	- - -	6.	- - -	216.2	76.1	143.8	24.1	26.8	81.2	6.5	5.1
	Exp.	"	252	272	18	72	54	- - -	- - -	- - -	412.4	124.8	277.9	46.5	56.9	150.4	12.7	5.1
JERSEY LILY	III. Pre.	glu.	112	292	10	40	30	8.5	- - -	- - -	251.2	77.4	170.5	32.4	31.1	93.2	7.9	4.4
	Exp.	"	209	511	18	72	54	18.	- - -	- - -	445.6	142.5	309.8	60.4	56.3	168.1	14.2	4.2
	IV. Pre.	No. 1	118	297	10	40	30	3.	- - -	- - -	239.9	71.1	169.9	29.1	32.1	95.0	7.9	5.0
	Exp.	"	204	539	18	72	54	- - -	- - -	- - -	431.0	123.1	288.2	48.0	55.8	160.4	13.7	5.1
	V. Pre.	glu.	115	297	10	40	30	10.	- - -	- - -	251.4	79.0	172.3	32.9	34.8	90.2	7.5	4.3
	Exp.	"	203	530	18	72	54	18.	- - -	- - -	456.7	139.5	319.9	59.0	63.6	173.0	13.8	4.5
	VI. Pre.	No. 1	119	280	10	40	30	- - -	- - -	- - -	253.6	70.8	169.9	25.7	35.6	95.4	7.5	5.8
	Exp.	"	206	499	18	72	54	- - -	- - -	- - -	449.2	128.6	300.3	46.4	62.5	168.7	13.3	5.6
	VII. Pre.	glu.	114	247	10	39	30	8.5	- - -	- - -	249.1	77.3	165.0	31.4	32.1	87.6	7.3	4.3
	Exp.	"	260	303	18	70	54	18.	- - -	- - -	441.7	139.7	301.9	59.2	59.5	156.9	13.3	4.2

Name of cow	Buckwheat middlings vs. cottonseed, linseed and corn meals and bran Period numbers	Nature of ration	Pounds eaten of						Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period					Nutritive ratio, 1:
			Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Buckwheat middlings			Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	
IDARELLA	I. Preliminary	B. M.	109	354	10	28	18	18	218.5	64.4	172.8	25.5	36.8	96.0	8.1	5.9
	Experimental	"	204	648	..	..	..	119	460.5	107.0	312.1	50.8	65.8	167.9	16.7	5.3
	II. Preliminary	No. 1	114	355	9	37	28	6	241.2	68.6	165.0	26.6	34.7	90.1	7.4	5.3
	Experimental	"	202	646	18	72	54	---	460.9	124.0	319.7	47.6	69.1	177.0	14.5	5.9
	III. Preliminary	B. M.	112	360	1	3	2	67	257.0	65.5	176.1	30.4	32.3	98.3	9.7	5.0
	Experimental	"	207	643	..	..	..	121	444.0	108.9	312.2	52.9	58.2	174.3	17.1	5.1
	IV. Preliminary	No. 1	116	355	8	33	25	13	249.1	68.1	178.0	28.4	34.1	101.1	8.6	5.4
	Experimental	"	185	641	18	69	52	---	434.8	118.8	294.0	47.5	57.4	164.8	13.8	5.3
	V. Preliminary	B. M.	114	360	1	3	2	64	249.1	62.4	171.2	26.9	35.6	93.5	8.4	5.5
	Experimental	"	203	648	..	..	..	130	465.0	116.6	325.7	49.4	65.5	178.1	15.0	5.6
	VI. Preliminary	No 1	113	356	9	37	28	6	269.7	70.9	182.2	27.1	38.2	103.2	8.1	5.9
	Experimental	"	198	648	18	71	54	---	480.8	127.7	325.5	48.1	68.4	184.6	14.3	5.9
SUENETTE	I. Preliminary	No. 1	154	360	13	40	27	---	292.0	69.0	199.6	27.7	45.1	110.6	8.6	6.3
	Experimental	"	276	637	18	72	54	---	536.4	123.8	355.8	51.0	80.7	195.0	15.5	6.1
	II. Preliminary	B. M.	151	356	1	3	2	73	274.4	70.8	187.2	32.6	39.1	98.6	9.8	4.9
	Experimental	"	263	640	..	..	..	135	510.8	122.1	351.6	57.6	75.3	187.4	18.7	5.3
	III. Preliminary	No. 1	154	360	10	40	30	---	297.7	69.6	197.8	30.1	39.7	112.1	9.0	5.7
	Experimental	"	285	622	18	72	54	---	520.3	125.9	354.7	54.2	71.4	200.7	16.1	5.7
	IV. Preliminary	B. M.	158	359	2	7	5	56	279.1	62.2	196.1	31.7	38.5	109.3	10.1	5.4
	Experimental	"	272	643	..	..	..	109	491.5	99.1	324.9	53.2	65.5	177.2	16.8	5.3
	V. Preliminary	No. 1	152	358	9	37	28	6	289.5	69.9	194.6	29.0	43.3	106.2	8.4	5.8
	Experimental	"	280	638	18	72	54	---	536.2	123.1	367.6	52.2	81.1	206.7	15.4	6.2
	VI. Preliminary	B. M	157	340	1	3	2	52	285.4	52.3	190.6	25.9	42.6	107.0	8.4	6.5
	Experimental	"	278	639	2	2	..	118	531.7	108.2	358.3	50.6	77.2	201.9	16.4	6.2
	VII. Preliminary	No. 1	144	349	7	29	22	20	295.7	68.7	193.9	29.4	41.0	107.3	8.6	5.7
	Experimental	"	303	415	18	72	54	---	491.3	124.8	332.8	51.6	71.4	181.3	14.5	5.5
BUTTERCUP	I. Preliminary	B. M	115	297	4	4	..	49	225.1	51.1	155.8	23.6	33.7	84.7	7.9	5.8
	Experimental	"	202	535	..	..	..	104	414.3	93.5	278.[illegible]	45.0	59.9	149.1	14.7	6.5
	II. Preliminary	No. 4	118	296	28	29	..	4	217.2	54.2	148.8	16.4	31.2	88.8	5.9	8.1
	Experimental	"	206	537	54	54	..	---	409.6	96.3	283.9	28.4	60.8	171.3	11.3	9.1
	III. Preliminary	B. M.	113	299	2	2	..	36	112.5	36.0	142.6	20.8	29.0	80.8	6.9	6.0
	Experimental	"	215	540	..	..	..	101	406.5	90.9	282.3	46.6	54.4	157.0	15.0	5.3
	IV. Preliminary	No. 4	120	300	25	26	..	9	224.5	53.2	159.6	18.7	30.3	97.8	6.9	7.7
	Experimental	"	213	636	54	54	..	---	433.4	94.2	292.9	32.0	57.2	179.9	12.1	8.3
	V. Preliminary	B. M.	117	360	2	3	..	40	229.3	39.9	156.2	20.8	35.5	86.2	6.9	7.1
	Experimental	"	216	648	..	..	..	75	426.9	67.2	295.7	37.6	66.9	168.0	12.8	7.0
	VI. Preliminary	No. 4	112	352	28	28	..	4	250.1	53.3	170.4	17.0	34.7	105.1	6.6	9.1
	Experimental	"	208	648	54	54	..	---	455.5	93.3	313.0	30.1	66.0	193.8	11.9	9.5
SERENA	I. Preliminary	No. 4	93	289	40	40	..	---	224.4	70.9	158.3	16.5	30.2	98.7	6.6	8.7
	Experimental	"	176	523	71	72	..	---	421.4	126.3	289.3	30.1	55.9	179.6	12.0	8.7
	II. Preliminary	B. M.	100	299	3	3	..	72	218.9	70.1	151.5	28.5	28.5	80.7	8.6	4.5
	Experimental	"	175	537	..	..	..	115	390.3	104.1	272.8	46.6	55.8	146.0	15.1	5.1
	III. Preliminary	No. 4	94	291	37	37	..	6	229.6	71.0	158.5	18.5	26.9	110.8	7.1	8.3
	Experimental	"	170	503	72	72	..	---	394.4	125.6	280.6	31.2	47.4	180.3	12.2	8.2
	IV. Preliminary	B. M	100	299	7	7	..	46	208.1	53.7	149.5	23.5	27.6	85.7	7.8	5.6
	Experimental	"	173	539	..	..	..	119	388.0	107.1	263.5	48.6	47.9	143.0	15.1	4.6
	V. Preliminary	No. 4	96	300	37	37	..	5	225.6	69.0	157.0	17.2	30.0	96.7	6.5	8.2
	Experimental	"	170	540	72	72	..	---	417.4	126.4	295.1	29.9	55.3	188.0	11.8	9.0

Name of cow	Medium and wide rations	Nature of ration	Pounds eaten of						Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period					Nutritive ratio, 1 :
	Period numbers		Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Quaker dairy feed			Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	
DIME	IV. Preliminary	No. 1	119	299	8	33	25	14	239.4	69.3	167.6	25.9	32.9	95.7	7.7	5.6
	Experimental	"	211	540	18	72	54	...	437.4	123.1	291.9	48.4	56.8	162.3	13.8	5.2
	V. Preliminary	Q. D. F.	116	298	1	3	2	74	247.1	73.6	160.6	18.7	38.0	91.5	6.0	7.6
	Experimental	"	210	527	--	--	--	144	455.1	132.5	300.1	32.5	70.5	176.5	11.0	8.4
	VI. Preliminary	No. 1	118	297	9	38	27	6	257.7	71.0	172.3	25.6	36.5	97.3	7.5	5.9
	Experimental	"	206	539	18	72	54	...	460.8	128.6	308.9	47.1	64.6	173.9	13.6	5.7
	VII. Preliminary	Q. D. F.	110	298	3	11	8	57	253.4	71.6	162.4	20.8	36.5	92.8	6.4	6.9
	Experimental	"	266	314	--	--	--	143	440.6	130.7	285.0	33.9	67.4	161.6	10.7	7.5
EVA	II. Preliminary	No. 1	114	359	10	40	30	...	242.0	68.5	164.2	26.2	35.0	90.6	7.3	5.4
	Experimental	"	199	643	18	72	54	...	457.5	124.0	317.7	47.4	68.5	175.9	14.4	5.8
	III. Preliminary	Q. D. F.	109	358	1	3	2	66	254.5	66.1	166.8	20.0	35.9	99.0	6.7	7.5
	Experimental	"	214	644	--	--	--	135	465.3	124.2	311.7	36.7	67.9	185.0	12.4	7.7
	IV. Preliminary	No. 1	117	358	8	33	25	14	251.9	69.3	178.3	26.7	35.2	102.5	8.1	5.8
	Experimental	"	195	648	18	72	54	...	449.5	123.1	303.3	49.1	59.2	169.9	14.3	5.3
	V. Preliminary	Q. D. F.	111	360	1	3	2	70	254.0	69.9	166.7	19.0	39.7	94.9	6.3	7.8
	Experimental	"	195	643	--	--	--	130	459.7	119.6	307.6	32.2	72.5	181.6	11.3	8.7
	VI. Preliminary	No. 1	108	328	10	38	30	...	255.6	69.0	172.3	25.9	36.1	97.5	7.6	5.8
	Experimental	"	205	537	18	72	54	...	458.4	128.6	307.4	46.9	64.2	173.2	13.6	5.7
	VII. Preliminary	Q. D. F.	111	299	3	11	8	53	251.0	68.0	160.9	20.4	36.3	91.7	6.3	7.0
	Experimental	"	261	312	--	--	--	133	426.6	121.6	276.2	32.5	65.7	156.4	10.3	7.5
JIP	I. Preliminary	No. 1	102	285	12	36	24	...	222.1	62.1	153.3	22.5	32.8	85.6	6.9	6.0
	Experimental	"	188	434	16	62	47	...	388.6	107.5	259.1	39.9	56.1	142.0	11.7	5.6
	II. Preliminary	Q. D. F.	105	195	5	22	15	34	197.2	67.1	130.1	19.4	28.9	71.5	5.4	5.8
	Experimental	"	183	357	--	--	--	130	368.4	119.8	237.8	27.4	58.2	134.2	8.9	7.8
	III. Preliminary	No. 1	106	196	9	38	27	6	213.4	69.9	141.0	24.2	26.2	79.2	6.8	5.0
	Experimental	"	177	354	18	70	54	...	363.9	124.1	246.6	43.4	44.9	138.1	12.1	4.8
	IV. Preliminary	Q. D. F.	107	198	2	7	5	64	207.2	71.1	137.8	18.7	28.7	80.4	5.8	6.5
	Experimental	"	201	359	--	--	--	141	392.2	130.3	245.7	31.9	53.3	142.3	9.9	6.8
	V. Preliminary	No. 1	113	197	9	37	27	6	215.8	69.2	144.2	23.6	30.2	78.6	6.5	5.2
	Experimental	"	205	357	18	72	54	...	396.4	123.1	271.0	41.1	55.6	150.8	12.2	5.3
	VI. Preliminary	Q. D. F.	108	188	1	3	2	54	202.6	55.1	129.9	14.6	30.9	75.3	4.7	8.0
	Experimental	"	200	357	--	--	--	123	390.5	113.2	248.5	27.3	59.0	145.0	8.9	8.2
MAIZIE	II. Preliminary	No. 1	89	238	10	40	30	...	194.6	68.4	133.2	23.2	26.4	72.6	6.2	4.9
	Experimental	"	165	432	18	72	54	...	375.4	124.0	258.7	42.5	52.9	142.2	12.2	5.2
	III. Preliminary	Q. D. F.	79	238	1	3	2	73	203.5	72.6	132.0	17.2	27.1	78.6	5.5	6.9
	Experimental	"	174	421	--	--	--	142	381.9	130.6	251.5	31.6	53.2	149.1	10.2	7.1
	IV. Preliminary	No. 1	90	233	8	33	25	14	199.6	69.3	140.0	23.1	26.1	79.8	6.7	5.2
	Experimental	"	140	431	18	71	54	...	348.2	122.1	236.2	42.5	42.6	131.4	11.8	4.7
	V. Preliminary	Q. D. F.	62	239	1	3	2	74	185.5	73.6	121.4	15.1	26.8	70.4	4.9	7.2
	Experimental	"	134	432	--	--	--	142	361.7	130.6	239.5	27.1	53.6	142.6	9.1	8.0
	VI. Preliminary	No. 1	64	232	9	38	27	6	192.0	71.0	130.6	22.0	24.8	74.1	6.2	5.1
	Experimental	"	96	430	18	72	54	...	330.6	128.6	228.1	39.9	41.7	129.3	11.2	4.9
	VII. Preliminary	Q. D. F.	60	238	3	11	8	50	184.6	65.2	120.0	16.4	25.4	69.3	4.9	6.4
	Experimental	"	103	178	--	--	--	142	263.0	129.8	270.4	22.7	36.0	99.6	6.8	6.6

Name of cow	Equal balance	Nature of ration	Pounds eaten of						Total dry matter in entire ration.	Total dry matter in experimental feed.	Pounds of digestible nutrients eaten during period					Nutritive ratio, 1 :
	Period numbers		Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Quaker dairy feed			Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	
MAX BELLE	I. Preliminary	No. 1	114	297	13	40	27	...	242.2	69.0	166.7	24.8	35.6	92.9	7.5	5.9
	Experimental	"	211	526	18	72	54	...	449.9	123.8	300.7	46.1	64.9	165.2	13.7	5.7
	II. Preliminary	Q. D. F.	111	290	6	23	17	34	226.3	70.5	150.9	21.9	33.6	83.5	6.2	6.0
	Experimental	"	205	531	..	..	..	144	443.7	132.8	291.2	32.6	71.2	165.2	11.0	8.0
	III. Preliminary	No. 1	114	296	9	38	27	6	246.5	69.9	164.8	26.3	31.7	93 8	7.7	5.4
	Experimental	"	214	527	18	71	54	..	436.4	125.0	299.9	48.4	57.6	169.8	14.1	5.4
	IV. Preliminary	Q. D. F.	116	297	2	7	5	65	239.2	72.1	162.4	20.9	34.4	95.5	6.7	6.9
	Experimental	"	204	538	..	..	..	143	439.8	132.1	280.5	35.0	61.4	163.3	11.2	7.1
	V. Preliminary	No. 1	112	295	9	38	27	6	239.3	70.0	161.6	25.3	34.5	88 6	7.2	5.5
	Experimental	"	204	527	18	72	54	...	440.4	123.1	304.8	46.7	63.6	171.6	13.5	5.7
	VI. Preliminary	Q. D. F.	117	245	1	3	2	68	239.3	68.0	154 2	17.3	36.2	89.9	5.7	8.0
	Experimental	"	202	353	..	..	..	139	405.9	127.9	257.8	28 9	60.5	150.9	9.4	8.0
	VII. Preliminary	No. 1	106	194	7	29	22	19	218.5	68.4	141.2	22.2	29.2	78.3	6.2	5.5
	Experimental	"	279	160	18	72	54	...	410.0	124.8	271.1	46.3	55.8	145.2	12.5	5.0
DANDELION	II. Preliminary	No. 4	109	296	20	20	..	...	226.6	71.1	157.0	17.1	30.1	96.8	6.3	8.3
	Experimental	"	192	533	72	72	..	...	428.5	128.4	300 2	31.1	59.0	185.4	12.4	8.8
	III. Preliminary	Q. D. F.	105	298	3	3	..	64	233.7	64.5	152.1	18.0	32.4	90.7	6.1	7.6
	Experimental	"	206	511	..	..	..	110	401.8	101.2	267.0	31.5	58.9	157.3	10.5	7.6
	IV. Preliminary	No. 4	114	289	33	33	..	11	232.1	68.5	164.5	18.4	30.0	103.4	7.0	8.1
	Experimental	"	188	527	71	72	..	...	415.8	124.7	284.2	32.2	49.8	179.1	12.3	8.0
	V. Preliminary	Q. D. F.	107	285	3	3	..	44	208.4	45.9	136.6	14 5	33.4	77.8	5.0	8.4
	Experimental	"	178	526	..	..	..	89	376.2	81.9	251.4	25.6	60.8	147.5	9.0	8.9
FAIRIE	II. Preliminary	No. 4	101	298	40	40	..	...	220.4	71.1	153.2	16.8	28.8	94.9	6.2	8.2
	Experimental	"	176	533	72	72	..	...	414.5	128.4	292.0	30.3	56.4	181 3	12.2	8.8
	III. Preliminary	Q. D. F.	105	297	3	3	..	73	241.8	72.8	157.0	19.0	33.1	93 8	6.3	7.4
	Experimental	"	210	534	..	..	..	141	439.6	129.7	291.3	35.4	62.9	172.3	11.6	7.4
	IV. Preliminary	No. 4	116	295	33	33	..	13	237 0	70.3	167.9	18 9	30.7	05.4	7.1	8.0
	Experimental	"	185	539	71	72	..	...	416.1	124.7	284.8	32.2	49.9	179.6	12.3	8.0
	V. Preliminary	Q. D. F.	102	298	3	3	..	70	231.1	69.9	151.0	17.0	35.3	87.1	5.7	8.0
	Experimental	"	186	537	..	..	..	139	432.1	127.9	286.6	31.0	66.7	169.2	10.6	8.4
GOLDENROD	I. Preliminary	No. 4	154	360	25	40	15	...	292.8	69.9	201.4	24.5	44.4	116.0	8.4	7.3
	Experimental	"	268	643	72	72	..	...	534.5	127.2	361.3	36.6	76.6	218.5	14 5	9.0
	II. Preliminary	Q. D. F.	152	359	23	23	..	34	277.2	72.0	185.4	20.3	41.8	108.4	6.9	8.2
	Experimental	"	273	645	..	..	..	144	531.5	132.8	348.4	37.6	87.7	196.2	12.9	8.3
	III. Preliminary	No. 4	150	360	37	37	..	6	295.9	71.2	198.9	21.8	37.7	124.0	8.3	8.3
	Experimental	"	285	639	72	72	..	...	524.4	125.6	364.9	39.9	68.8	227.5	15.3	8.3
	IV. Preliminary	Q. D. F.	159	357	7	7	..	66	290.6	73.4	197.2	23.0	42.5	117.1	7.8	7.7
	Experimental	"	274	648	..	..	..	144	528.5	133.1	335.8	40 8	75.6	194 1	13.2	7.3

Name of cow	Equal balance; grooming vs. non-grooming Period numbers	Nature of ration	Pounds eaten of						Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period					Nutritive ratio, 1:
			Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Quaker dairy feed			Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	
ROWENA	I. Preliminary	No. 4	113	356	25	40	15	---	257.8	69.9	179.6	22.5	37.5	105.0	7.7	7.1
	Experimental	"	200	628	72	72	--	---	471.8	127.2	323.6	33.1	64.8	199.2	13.3	8.9
	II. Preliminary	Q. D. F.	110	348	27	27	--	25	238.6	70.8	162.5	18.0	33.9	97 5	6.3	8.1
	Experimental	"	187	639	--	--	--	139	450.2	128.2	300.5	32.9	72.9	171.6	11.4	8.2
	III. Preliminary	No. 4	103	345	36	37	--	6	250.1	70.3	171.9	18.8	30.7	109.2	7.3	8.3
	Experimental	"	212	611	69	69	--	---	454.8	123.8	319.0	34.7	57.7	201.8	13.6	8.4
	IV. Preliminary	Q. D. F.	116	349	7	7	--	56	243.7	64 1	168.5	19.4	35.6	111.2	6.8	8.4
	Experimental	"	190	647	--	--	--	135	446.4	124.7	288.6	35.0	63.6	168.7	11.5	7.4
	V. Preliminary	No. 4	114	344	36	37	--	5	251.0	68.2	173.1	18.1	35.1	105.7	6.8	8.6
	Experimental	"	197	630	72	72	--	---	464.7	126.4	327.6	32.6	63.9	206.8	12.9	9.2
	VI. Preliminary	Q. D. F.	111	289	3	3	--	57	236.2	57.9	153.8	16.0	36.3	90.7	5.6	8.7
	Experimental	"	200	529	--	--	--	125	438.2	115.0	284 3	30.2	67.4	167.1	10.4	8.5
	VII. Preliminary	No. 4	109	294	29	29	--	16	245.0	65.2	162.6	17.9	32.8	98.8	6.4	8.2
	Experimental	"	233	320	71	72	--	---	407.4	125.3	282.0	31.9	53.1	173.0	11.6	7.9
VIOLA	V. Preliminary	Q. D. F.	88	300	--	--	--	76	219.8	70.2	143.5	16.4	33.6	82.5	5.4	7.8
	Experimental	"	151	540	--	--	--	139	402.3	127.9	268.6	29.3	61.2	159.7	10.1	8.3
	VI. Preliminary	No. 4	90	296	40	40	--	---	232.7	71.0	160.8	16.3	29.8	102.7	6.5	9.0
	Experimental	"	165	539	72	72	--	---	418.4	124.4	292.2	29.6	54.5	186.5	11.8	9.0
	VII. Preliminary	Q. D. F.	95	298	11	11	--	42	225.6	57.7	146.7	16.3	32.4	86.7	5.5	8.1
	Experimental	"	230	325	--	--	--	116	386.5	106.0	252.3	29.4	60.2	143.2	9.4	7.6
BETTIE	II. Preliminary	gro'm'd	115	299	10	40	30	---	229.6	68.5	156.2	25.4	32.9	85.1	6.9	5.3
	Experimental	"	195	535	18	72	54	---	427.2	124.0	294.3	45.5	62.7	162.1	13.5	5.6
	III. Preliminary	not gr	109	297	10	40	30	---	242.1	69.6	162.9	26.5	30.9	92.4	7.7	5.3
	Experimental	"	214	530	18	72	54	---	438.0	125.9	301.1	48.7	57.8	170.5	14.2	5.3
	IV. Preliminary	gro'm'd	120	299	10	40	30	---	239.3	68.3	168.8	27.2	32.4	95.6	7.9	5.4
	Experimental	"	203	633	18	72	54	--	452.9	123.1	304.6	49.3	59.7	170.3	14.3	5.3
	V. Preliminary	not gr	109	351	10	40	30	---	249.9	69.8	170.5	26.7	36.2	93.3	7.7	5.5
	Experimental	"	203	640	18	72	54	---	469.4	123.1	327.2	47.4	68.8	185.4	14.4	6.0
	VI. Preliminary	gro'm'd	104	224	8	35	26	---	215.1	61.1	143.6	22.2	30.1	80.5	6.3	5.6
	Experimental	"	203	360	18	72	54	---	409.3	128.6	270.6	44.0	55.5	150.6	12.2	5.3
POLELA	IV. Preliminary	not gr	115	284	10	40	30	---	231.5	68.3	163.3	26.6	31.1	92.4	7.8	5.3
	Experimental	"	199	540	18	72	54	---	426.9	123.1	285.9	47.7	55.2	159.2	13.6	5.1
	V. Preliminary	gro'm'd	112	296	10	40	30	---	239.3	69.8	162.2	25.9	34.3	88.6	7.3	5.4
	Experimental	"	205	538	18	72	54	---	444.2	123.1	307.6	46.9	64.3	173.3	13.6	5.7
	VI. Preliminary	not gr	113	296	10	40	30	---	252.8	70.8	169.9	26.0	35.4	95.7	7.5	5.7
	Experimental	"	208	537	18	72	54	---	461.1	128.6	309.0	47.1	64.7	174.0	13.6	5.7
	VII. Preliminary	gro'm'd	115	300	10	40	30	---	257.3	70.3	169.3	26.8	34.8	93.7	7.5	5.4
	Experimental	"	310	320	18	72	54	---	475.2	124.8	318.4	50.5	68.1	172.3	14.0	5.4
SALIDA	IV. Preliminary	not gr	---	---	--	--	--	---	----	----	----	- --	-- -	----	-- -	- -
	Experimental	"	201	432	18	69	53	---	399.0	119.5	265.0	45.4	50.7	146.6	12.7	5.0
	V. Preliminary	gro'm'd	117	263	10	40	30	---	235.8	69.8	159.0	25.7	33.6	86.6	7.1	5.3
	Experimental	"	208	537	18	72	54	---	446.5	123.1	309.0	47.1	64.7	174.0	13.6	5.7
	VI. Preliminary	not gr	115	298	10	40	30	---	255.2	70.8	171.3	26.1	35.8	96.5	7.6	5.7
	Experimental	"	207	537	18	72	54	---	460.2	128.6	308.5	47.0	64.6	173.7	13.6	5.7
	VII. Preliminary	gro'm'd	113	299	10	40	30	---	255.2	70.3	168.0	26.7	34.4	93.0	7.5	5.4
	Experimental	"	270	325	18	72	54	---	440.8	124.8	297.8	48.4	62.2	161.6	13.3	5.2

Name of cow	Watering at will and at intervals	Manner of giving water	Pounds eaten of									Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period					Nutritive ratio, 1:
	Period numbers		Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Water	Average temperature	Water	Average temperature			Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	
FLORA	V. Pre.	will	109	323	10	40	30	929	..	----	----	243.1	69.8	165.5	26.2	35.0	90.5	7.4	5.4
	Exp.	"	196	642	18	72	54	1547	..	----	----	463.8	123.1	323.9	48.1	67.8	183.6	14.3	5.9
	VI. Pre.	int	115	316	10	40	30	----	..	921	----	260.2	70.8	174.9	26.4	36.7	98.7	7.7	5.8
	Exp.	"	205	535	18	72	54	----	..	1651	----	457.9	128.6	307.0	46.9	64.1	172.9	13.6	5.7
	VII. Pre.	will	105	299	10	40	30	1048	..	----	----	247.8	70.3	163.7	26.2	33.2	90.7	7.3	5.4
	Exp.	"	230	315	18	72	54	1845	..	----	---	403.0	124.8	274.3	46.0	55.6	149.2	12.5	5.1
L'Y PERUSIA	V. Pre.	will	117	299	10	40	30	620	..	----	----	244.5	69.8	165.4	26.2	35.2	90.3	7.4	5.4
	Exp.	"	212	538	18	72	54	1221	..	----	----	450.3	123.1	311.3	47.3	65.4	175.2	13.7	5.7
	VI. Pre.	int	118	297	10	40	30	----	..	687	----	257.5	70.8	172.7	26.2	36.3	97.2	7.6	5.7
	Exp.	"	212	540	18	72	54	----	..	1350	----	465.6	128.6	311.7	47.3	65.5	175.5	13.7	5.7
	VII. Pre.	will	116	300	10	40	30	819	..	----	----	258.3	70.3	169.8	26.9	34.9	93.9	7.5	5 4
	Exp.	"	286	330	18	72	54	1516	..	----	----	456.2	124.8	307.3	49.3	64.9	166.7	13.7	5.3
MAX ELLA	IV. Pre.	will	116	358	10	40	30	648	..	----	----	250 0	68.3	178.5	27.9	34 5	101.9	8.3	5.6
	Exp.	"	198	644	18	72	54	1419	..	----	----	451.1	123.1	304.1	49.2	59.5	170.2	14.3	5.3
	V. Pre.	int	113	359	10	40	30	----	..	684	----	255.4	69.8	174.0	27.0	37.2	95.2	7.8	5.6
	Exp.	"	202	645	18	72	54	----	..	1323	----	469.8	123.1	327.6	48.5	68.9	185.7	14.4	5.9
	VI. Pre.	will	116	343	10	40	30	870	..	----	----	268.5	70.8	181.0	26.9	38.2	102.3	7 9	5.9
	Exp.	"	200	637	18	70	54	1486	..	----	----	478.8	126.8	323.7	47.9	68.1	183.5	14.2	5.9
	VII. Pre.	int	105	354	10	40	30	----	..	817	----	262.6	70.3	174.2	27.1	35.8	97.0	7.6	5.5
	Exp.	"	235	407	18	72	54	----	..	1451	----	429.0	124.8	294.5	47.7	60.7	161.2	13.2	5.3
M. BELLA	V. Pre.	int	116	290	10	40	30	---	..	685	----	241.4	69.8	163.3	26.0	34.6	89.1	7.3	5.4
	Exp.	"	208	534	18	72	54	---	..	1324	----	445.7	123.1	308.4	47.0	64.6	173.6	13.6	5.7
	VI. Pre.	will	118	297	10	40	30	792	..	----	----	257.5	70.8	172.7	26.2	36.3	97.2	7.6	5.7
	Exp.	"	203	538	18	72	54	1323	..	----	----	456.9	128.6	306.6	46.8	64.0	172.7	13.6	5.7
	VII. Pre.	int	114	300	10	40	30	---	..	823	----	256.4	70.3	168.7	26.8	34.6	93.4	7.5	5.4
	Exp.	"	256	330	18	72	54	---	..	1501	----	429.6	124.8	291.1	47.7	60.3	158.2	13.1	5.2
ATALANTA	I. Pre.	warm'd	114	357	13	40	27	----	..	----	----	258.1	69.0	178.5	25.7	38.4	99.9	8.0	6.1
	Exp.	"	205	627	18	72	54	1500	70	----	----	472.4	123.8	317.5	47.5	68.7	175.5	14.3	5.8
	II. Pre.	cold	114	349	10	40	30	----	..	616	48	239.8	68.5	163.6	26.1	34.6	89.6	7.2	5.4
	Exp.	"	198	637	18	72	54	----	..	1158	46	455.1	124.0	316.0	47.3	68.0	174.9	14.3	5.8
	III. Pre.	warm'd	110	350	10	40	30	800	70	----	----	256.8	69.6	173.9	27.4	33.4	99.3	8.2	5.5
	Exp.	"	214	601	18	72	54	1254	70	----	----	456.1	125.9	315.2	49.8	60.9	179.4	14.8	5.5
	IV. Pre.	cold	118	341	10	40	30	----	..	580	42	247.6	68.3	176.1	27.7	34.0	100.3	8.2	5.5
	Exp.	"	203	642	18	72	54	----	..	991	42	455.0	123.1	306.3	49.5	60.0	171.3	14.4	5.3
	V. Pre.	warm'd	114	344	10	40	30	575	70	----	----	252.6	69.8	171.8	26.8	36.7	94.0	7.7	5.5
	Exp.	"	200	626	18	72	54	1063	70	----	----	463.1	123.1	322.7	48.1	67.7	182.8	14.2	5.9
	VI. Pre.	cold	117	307	10	38	30	----	..	545	42	257.6	69.0	172.9	26.0	36.5	97.5	7.6	5.8
	Exp.	"	202	509	17	69	52	----	..	1075	43	442.9	123.2	296.3	45.2	62.2	166.8	13.1	5.7

Name of cow	Warm and cold water / Period numbers	Manner of giving water	Pounds eaten of									Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period					Nutritive ratio, 1 :
			Hay	Silage	Corn meal	Wheat bran	½ cottonseed meal ½ linseed meal	Warmed water	Average temperature	Cold water	Average temperature			Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	
CLARE	I. Pre.	warm'd	159	360	13	40	27	----	--	----	----	296.1	69.0	202.1	27.9	45.9	111.9	8.7	6.4
	Exp.	"	283	634	18	72	54	1785	70	----	----	541.7	123.8	358.8	51.3	81.7	196.5	15.6	6.1
	II. Pre.	cold	158	360	10	40	30	----	--	760	48	278.9	68.5	187.9	28.3	42.2	102.0	7.9	5.7
	Exp.	"	280	647	18	72	54	----	--	1333	46	529.4	124.0	359.8	51.3	81.9	197.3	15.6	6.1
	III. Pre.	warm'd	158	360	10	40	30	842	70	----	----	301.2	69.6	199.8	30.3	40.2	113.2	9.1	5.7
	Exp.	"	286	637	18	72	54	1638	70	----	----	524.9	125.9	358.2	54.4	72.2	202.8	16.3	5.7
	IV. Pre.	cold	159	357	10	40	30	----	--	711	42	285.5	68.3	199.7	30.3	40.2	113.1	9.1	5.7
	Exp.	"	277	647	18	72	54	----	--	1245	42	520.8	123.1	344.1	53.8	70.2	191.3	15.7	5.5
EDNA	I. Pre.	warm'd	109	345	13	40	27	----	--	----	----	250.7	69.0	173.6	25.3	37.0	97.2	7.8	6.0
	Exp.	"	204	630	18	69	53	2062	70	----	----	469.0	120.4	315.1	46.7	68.5	174.3	14.2	5.9
	II. Pre.	cold	117	357	10	40	30	----	--	807	48	244.0	68.5	166.5	26.3	35.4	91.1	7.3	5.4
	Exp.	"	210	648	18	72	54	----	--	1351	46	468.4	124.0	324.2	48.0	70.5	179.3	14.6	5.9
	III. Pre.	warm'd	117	360	10	40	30	1001	70	----	----	265.5	69.6	179.4	28.0	34.8	102.4	8.4	5.6
	Exp.	"	211	634	18	72	54	1652	70	----	----	462.0	125.9	320.2	50.1	62.0	182.7	15.0	5.6
	IV. Pre.	cold	120	354	10	40	30	----	--	720	42	252.5	68.3	179.7	28.0	34.9	102.5	8.4	5.6
	Exp.	"	210	644	18	72	54	----	--	1170	42	461.6	123.1	310.1	49.9	61.1	173.4	14.5	5.4
	V. Pre.	warm'd	118	347	10	38	30	809	70	----	----	255.0	68.0	173.2	26.6	37.4	94.7	7.7	5.6
	Exp.	"	210	634	18	72	54	1444	70	----	----	473.9	123.1	329.7	48.7	69.7	186.6	14.4	5.9
	VI. Pre.	cold	117	348	10	40	30	----	--	749	42	270.8	70.8	182.5	27.0	38.6	103.2	8.0	5.9
	Exp.	"	201	620	18	70	54	----	--	1356	42	475.2	126.8	320.7	47.6	67.5	181.6	14.1	5.9
	VII. Pre.	warm'd	110	295	10	38	30	809	70	----	----	249.6	68.6	164.4	26.1	33.7	91.0	7.3	5.4
	Exp.	"	244	317	18	72	54	1652	70	----	----	415.8	124.8	282.1	46.8	57.8	153.4	12.8	5.1
ORPHA	II. Pre.	warm'd	100	190	8	34	25	653	70	----	----	182.1	57.2	123.0	20.5	25.9	66.5	5.5	5.1
	Exp.	"	196	359	18	72	54	1283	70	----	----	384.5	124.0	260.1	42.8	54.6	141.6	12.1	5.2
	III. Pre.	cold	112	198	10	39	30	----	--	636	44	217.8	68.6	144.1	24.9	26.9	80.5	7.0	4.9
	Exp.	"	211	350	18	72	54	----	--	1207	43	389.9	125.9	264.0	45.6	49.4	147.2	12.8	4.9
	IV. Pre.	warm'd	119	197	10	40	30	619	70	----	----	214.0	68.3	148.1	25.5	27.8	82.6	7.2	5.0
	Exp.	"	203	360	18	72	54	1180	70	----	----	387.1	123.1	255.5	45.2	48.1	140.6	12.4	4.8
	V. Pre.	cold	113	199	10	40	30	----	--	582	42	216.9	69.8	145.5	24.5	30.1	79.1	6.6	5.1
	Exp.	"	205	359	18	72	54	----	--	1075	42	396.9	123.1	271.4	44.1	55.7	151.1	12.2	5.3
	VI. Pre.	warm'd	111	197	10	39	30	656	70	----	----	222.5	69.9	148.1	24.1	30.3	82.5	6.7	5.3
	Exp.	"	200	358	18	71	54	1263	70	----	----	405.2	127.7	268.0	43.7	54.8	149.2	12.1	5.3
	VII. Pre.	cold	102	197	10	39	30	----	--	706	44	216.6	69.4	142.0	24.3	27.9	77.8	6.6	5.0
	Exp.	"	232	170	18	72	54	----	--	1372	48	370.7	124.8	247.7	43.8	49.1	133.1	11.7	4.8
RED TOP	I. Pre.	cold	116	358	13	40	27	----	--	----	----	259.9	69.0	179.8	25.8	38.8	100.6	8.0	6.1
	Exp.	"	206	641	18	72	54	----	--	1386	49	477.1	123.8	320.9	47.7	69.5	177.5	14.5	5.9
	II. Pre.	warm'd	112	357	10	40	30	740	70	----	----	239.8	68.5	163.9	26.1	34.5	89.8	7.2	5.4
	Exp.	"	201	646	18	71	54	1146	70	----	----	459.1	123.1	318.6	47.4	68.9	176.4	14.4	5.9
	III. Pre.	cold	113	357	10	40	30	----	--	551	43	261.2	69.6	176.8	27.7	34.1	101.0	8.3	5.6
	Exp.	"	213	628	18	70	53	----	--	1034	43	459.4	123.2	318.2	49.6	61.9	181.5	14.8	5.6
SYLVIA	I. Pre.	cold	118	360	13	40	27	----	--	----	----	262.1	69.0	181.2	26.0	39.2	101.3	8.1	6.1
	Exp.	"	208	635	18	72	54	----	--	1427	49	477.2	123.8	320.7	47.7	69.6	177.3	14.5	5.9
	II. Pre.	warm'd	115	358	10	40	30	806	70	----	----	242.6	68.5	165.7	26.2	35.1	90.7	7.3	5.4
	Exp.	"	203	648	18	72	54	1387	70	----	----	462.3	124.0	320.6	47.7	69.4	177.5	14.5	5.9
	III. Pre.	cold	114	360	10	40	30	----	--	677	43	262.9	69.6	177.9	27.8	34.3	101.6	8.3	5.6
	Exp.	"	214	644	18	72	54	----	--	1301	43	467.0	125.9	323.7	50.5	62.8	184.7	15.1	5.6
	IV. Pre.	warm'd	119	360	10	40	30	930	70	----	----	253.0	68.3	180.4	28.1	35.0	102.9	8.4	5.6
	Exp.	"	215	648	18	72	54	1634	70	----	----	466.9	123.1	313.3	50.2	61.9	175.1	14.6	5.4
	V. Pre.	cold	120	360	10	40	30	----	--	612	42	261.8	69.8	177.9	27.3	38.4	97.3	7.9	5.6
	Exp.	"	215	647	18	72	54	----	--	1082	42	481.8	123.1	334.9	49.1	71.1	189.6	14.6	6.0
	VI. Pre.	warm'd	117	355	10	40	30	823	70	----	----	272.8	70.8	183.9	27.1	38.9	104.1	8.0	5.9
	Exp.	"	193	641	18	72	54	1414	70	----	----	475.3	128.6	322.1	48.0	67.3	182.7	14.2	5.9

V. RECORDS SHOWING PRODUCTION AND SAME PER UNIT FOR EACH INDIVIDUAL COW IN FEEDING TESTS

Name of cow	Low, medium and high grain feeding / Period numbers	Experimental ration	Dry matter eaten *	Dry matter eaten †	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten in entire ration: Milk	Total solids	Fat
		No. 1	lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs
BEAUTINA	I. Preliminary	Low	258.4	54.4	237.4	15.16	5.53	35.99	13.13	91.9	13.9	5.1
	Experimental	"	422.9	61.9	385.0	14.84	5.26	57.13	20.25	91.0	13.5	4.8
	II. Preliminary	Medium	244.6	65.0	206.8	14.90	5.44	39.81	11.25	84.5	12.6	4.6
	Experimental	"	471.9	124.0	379.6	15.08	5.53	57.23	20.99	80.4	12.1	4.4
	III. Preliminary	High	292.3	95.5	220.1	15.24	5.57	33.54	12.27	75.3	11.5	4.2
	Experimental	"	526.6	186.2	442.7	15.03	5.27	66.51	23.35	84.1	12.6	4.4
	IV. Preliminary	Medium	254.3	71.7	228.8	14.94	5.24	34.17	12.00	90.0	13.4	4.7
	Experimental	"	464.3	123.1	399.1	14.99	5.35	59.83	21.34	86.0	12.9	4.6
	V. Preliminary	Low	226.0	34.9	208.5	15.05	5.35	31.38	11.15	92.3	13.9	4.9
	Experimental	"	420.5	61.6	364.4	15.18	5.42	55.32	19.76	86.7	13.2	4.7
	VI. Preliminary	Medium	273.3	68.1	216.4	15.46	5.56	33 46	12.03	79.2	12.2	4.4
	Experimental	"	495.4	128.6	388.5	15.06	5.39	58.51	20.95	78.4	11.8	4.2
	VII. Preliminary	High	294.2	92.3	218.4	14.97	5.26	32.68	11.48	74.2	11.1	3.9
	Experimental	"	516.7	187.3	412.9	14.55	4.98	60.06	20.58	79.9	11.6	4.0
DAHLIA		No. 1										
	I. Preliminary	Low	237.5	52.6	190.2	14.57	5.13	27.70	9.75	80.1	11.7	4.1
	Experimental	"	410.2	57.6	327.6	14.81	5.22	48.51	17.11	79.9	11.8	4.2
	II. Preliminary	Medium	227.8	59.0	163.0	15.20	5.66	24.78	9.23	71.6	10.9	4.1
	Experimental	"	449.5	118.8	319.3	15.37	5.79	49.07	18.50	71.0	10 9	4.1
	III. Preliminary	High	255.0	80.8	190.3	15.90	6 02	30.25	11.45	74.6	11.9	4.5
	Experimental	"	447.0	144.2	356.2	15.47	5.66	55.11	20.18	79.7	12.3	4.5
	IV. Preliminary	Medium	223.2	59.8	183.1	15.29	5.60	27.99	10.26	82.0	12.5	4.6
	Experimental	"	401.9	107.7	307.2	15.46	5.79	47.49	17.79	76.4	11.8	4.4
	V. Preliminary	High	242.4	74.1	169.5	15.91	6.05	26.96	10.26	69.9	11.1	4.2
	Experimental	"	429.0	141.1	314.4	15.48	5.70	48.66	17.93	73.3	11.3	4.2
	VI. Preliminary	Medium	226.3	64.6	171.4	15.63	5 85	26.79	10.03	75.7	11.8	4.4
	Experimental	"	410.7	117.0	302.6	15.56	5.85	47.09	17.67	73.7	11.5	4.3
	VII. Preliminary	"	221.7	62.4	169.5	15.38	5.78	26.07	9.79	76.5	11.8	4.4
	Experimental	"	393.4	123.1	309.0	15.07	5.53	46.59	17.10	78.5	11.8	4.3
ACME		No. 1				‡	‡					
	II. Preliminary	Medium	211.5	65.0	364.3	13.33	4.64	48.55	16.91	172.3	23.0	8.0
	Experimental	"	431.3	123.1	660.8	12.30	4.02	81.26	26.57	153.2	18.8	6.2
	III. Preliminary	High	255.0	93.0	351.5	12.43	3.93	43.69	13.82	137.8	17.1	5.4
	Experimental	"	468.9	187.9	659.6	12.22	3.71	80.65	24.45	140.7	17.2	5.2
	IV. Preliminary	Medium	240.5	71.7	326.9	12.09	3.75	39.53	12.26	135.9	16.4	5.1
	Experimental	"	430.9	123.1	514.1	12.06	3.76	61.98	19.32	119.3	14.4	4.5
	V. Preliminary	Low	206.8	34.9	244.7	12.14	3.89	29.71	9.53	118.3	14.4	4.6
	Experimental	"	381.8	61.6	416.3	11.82	3.72	49.21	15.50	109.0	12.9	4.1
	VI. Preliminary	Medium	230.5	68.1	233.3	12.28	3.80	28.65	8.86	101.2	12.4	3.8
	Experimental	"	432.3	128.6	469 8	11.82	3.58	55.51	16.83	108.7	12.8	3.9
	VII. Preliminary	High	251.2	91.4	273.4	11.92	3.59	32.58	9.81	108.8	13.0	3.9
	Experimental	"	479.6	187.3	524.3	11.75	3.50	61.61	18.33	109.3	12.8	3.8
NANCY B		No. 1										
	II. Preliminary	Medium	274.9	70.9	352.6	12.19	3.70	43.00	13.04	128.3	15.6	4.7
	Experimental	"	519.7	124.0	578.3	12.01	3.71	69.45	21.43	111.3	13.4	4.1
	III. Preliminary	Low	261.8	34.8	314.9	12.06	3.50	37.97	11.02	120.3	14.5	4 2
	Experimental	"	460.6	62.9	564.4	11.92	3.45	67.24	19.45	122.5	14.6	4.2
	IV. Preliminary	Medium	279.4	63.2	310.0	11.90	3.50	36.90	10.84	111.0	13.2	3.9
	Experimental	"	518.0	123.1	530.9	12.03	3.64	63.87	19.34	102.5	12.3	3.7
	V. Preliminary	Low	255.3	34.9	239.1	11.80	3.54	28.21	8 46	93.7	11.1	3.3
	Experimental	"	473 3	61 6	418.7	11.91	3.54	49.85	14 82	88.5	10.5	3.1
	VI. Preliminary	Medium	301.2	70.8	270.9	12.33	3.73	33.39	10.11	90.0	11.1	3.4
	Experimental	"	546.1	128.6	495.6	12.22	3.68	60.56	18.23	90.8	11.1	3.3
	VII. Preliminary	High	304.3	73.8	268.2	12.05	3 61	32.33	9.68	88.1	10.6	3.2
	Experimental	"	534.3	187.3	494.1	12.18	3.62	60.17	17.88	92.5	11.3	3.3

* In entire ration. † In experimental feed.

‡ Cow had just calved. The high figures are due to a lingering colostral effect.

Name of cow	Low, medium and high grain feeding Period numbers	Experimental ration	Dry matter eaten *	Dry matter eaten †	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten in entire ration		
										Milk	Total solids *	Fat
ROSEMARY		No. 2	lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs
	I. Preliminary	Low	201.9	44.6	179.2	13.65	4.56	24.46	8.17	88.8	12.1	4.0
	Experimental	"	359.1	63.6	319.8	13.57	4.40	43.40	14.08	89.1	12.1	3.9
	II. Preliminary	Medium	218.3	67.6	191.6	13.62	4.53	26.08	8.68	87.8	11.9	4.0
	Experimental	"	419.1	127.4	349.2	14.10	4.76	49.25	16.62	83.3	11.8	4.0
	III. Preliminary	High	252.4	92.2	201.6	14.47	4.88	29.16	9.83	79.9	11.6	3.9
	Experimental	"	423.0	166.9	358 8	14 43	4.86	51.76	17.42	84.8	12.2	4.1
	IV. Preliminary	Medium	221.6	68.6	180.8	14.37	4 86	25.98	8.78	81.6	11 7	4.0
	Experimental	"	405.7	118.4	292.3	14.78	5.18	43.20	15.15	72.1	10.6	3.7
	V. Preliminary	Low	193.5	34.2	150.1	14.96	5 40	22.46	8.11	77.6	11.6	4.2
	Experimental	"	361.7	63.3	262.0	14 89	5.35	39.02	14.03	72.4	10.8	3.9
	VI. Preliminary	Medium	219.1	57.0	158.7	14.80	5.22	23.49	8.29	72.4	10.7	3.8
	Experimental	"	407.4	114.3	288.2	14.82	5.27	42.71	15.19	70.7	10.5	3.7
	VII. Preliminary	High	219.9	56.1	158.2	14.71	5.13	23.27	8.12	71.9	10.6	3.7
	Experimental	"	454.0	166.6	284.2	14.50	5.00	41.21	14.22	62.6	9.1	3.1
EULALIE		No. 2										
	I. Preliminary	Low	-- --	-- --	-- --	-- --	-- --	-- --	----	----	-- -	--
	Experimental	"	483.4	64.5	579.9	13.99	4.49	81 12	26.04	120.0	16.8	5.4
	II. Preliminary	Medium	276.7	67.6	319.0	13.93	4.72	44 45	15.06	115.3	16.1	5.4
	Experimental	"	534.5	127.4	566.6	14.50	5.00	82.17	28.34	106.0	15.4	5.3
	III. Preliminary	High	336.3	104.7	329 3	14.86	5.20	48.94	17.12	198.0	14.6	5.1
	Experimental	"	592.2	190.7	599.0	14.93	5.18	89.41	31.04	101.1	15.1	5.2
	IV Preliminary	Very high	345.6	128.2	316.3	15.06	5.30	47.63	16 77	91 5	13.8	4.9
	Experimental	"	652.5	255.4	564.4	15.14	5.34	85.42	30.15	86.5	13.1	4.6
	V. Preliminary	High	333.3	108.0	293.4	15.59	5.62	45.73	16.50	88.0	13.7	5.0
	Experimental	"	610.1	192.7	518.8	15.53	5.57	80.54	28.89	85.0	13.2	4.7
	VI. Preliminary	Medium	310.7	72.3	270.9	15.40	5.45	41.73	14.77	87.2	13.4	4.8
	Experimental	"	554.2	128.6	484.6	15.57	5.65	75.46	27.37	87.4	13.6	4 9
	VII. Preliminary	Low	303.9	67.5	271.7	15.49	5.60	42 08	15.22	89.4	13.8	5.0
	Experimental	"	443.9	74.2	434.8	14.94	5.28	64.94	22.97	98.0	14.6	5.2
POMONA		No. 2										
	III. Preliminary	High	267.1	100.2	210.1	16.18	6.09	33.99	12.80	78.7	12.7	4.8
	Experimental	"	469.8	180.1	437.0	15.32	5.51	66.95	24.06	93.0	14.3	5.1
	IV. Preliminary	Medium	242.0	74.9	240.2	15.27	5.52	36.69	13.27	99.3	15.2	5.5
	Experimental	"	427.6	128.2	414.0	15.58	5.74	64.49	23.77	96.8	15.1	5.6
	V. Preliminary	Low	209.8	36.0	205.3	15.60	5.82	42.03	11.94	97.9	15.3	5.7
	Experimental	"	389.3	64.2	353.5	15.52	5.78	54.87	20.45	90.8	14.1	5.3
	VI. Preliminary	Medium	250.8	72.3	208.9	15.82	6.04	33.04	12.62	83.3	13.2	5.0
	Experimental	"	454.1	128.6	380.2	15.54	5.89	59.07	22.40	83.7	13.0	4.9
	VII. Preliminary	High	256.0	85.1	219.0	15.50	5.79	33.94	12.68	85.6	13.3	5.0
	Experimental	"	495.2	192.5	404.2	15.15	5.53	61.25	22.35	81.6	12.4	4.5
INEZ		No. 3										
	I. Preliminary	Medium	-- --	-- -	-- --	-- --	- --	-- --	-- --	----	-- -	--
	Experimental	"	423.4	133.3	508.8	15.05	5.33	76.59	27.12	120.2	18.1	6.4
	II. Preliminary	"	217.3	74.4	283.7	14.64	5.40	41.54	15.31	130.6	19.1	7.0
	Experimental	"	400.6	126.8	477.8	15.08	5.68	72.05	27.13	119.3	18.0	6.8
	III. Preliminary	Low	191.6	35.7	241.3	15.01	5.52	36.22	13.31	126.0	18.9	6.9
	Experimental	"	334.9	64.4	416.1	15.08	5.59	62 77	23.28	124.2	18.7	7.0
	IV. Preliminary	Medium	225.5	66.2	222.4	15.52	6.01	34.52	13.37	98.6	15.3	5.9
	Experimental	"	443.4	127.4	408.4	15.92	6.24	65.00	25.49	92.1	14.7	5.7
	V. Preliminary	High	244.4	68.3	210.9	16.16	6.35	34.08	13.39	86.3	13.9	5.5
	Experimental	"	481.7	154.0	393.1	16.32	6.48	64.13	25.47	81.6	13.3	5.3
	VI. Preliminary	Medium	254.9	68.5	221.5	16.19	6.29	35.85	13.94	86.9	14.1	5.5
	Experimental	"	457.4	123.2	387.4	15.93	6.03	61.72	23.35	84.7	13.5	5.1

* In entire ration. † In experimental feed.

Name of cow	Low, medium and high grain feeding Period numbers	Experimental ration	Dry matter eaten *	Dry matter eaten †	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten in entire ration		
										Milk	Total solids	Fat
		No. 3	lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs
STAR BRIGHT	I. Preliminary	Low	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	- --	- -
	Experimental	"	362.0	63.1	372.2	13.77	4.48	51.25	16.69	102.8	14.2	4.6
	II. Preliminary	Medium	215.2	67.3	193.8	14.24	4.93	27 60	9.55	90.1	12.8	4.4
	Experimental	"	415.6	127.7	318.8	14.76	5.27	47.03	16.78	76.7	11.3	4.0
	III. Preliminary	High	262.5	102.5	171.8	15.54	5.73	26.70	9.84	65.4	10.2	3.7
	Experimental	"	473.8	193.3	318.7	15.60	5.73	49.70	18.27	67.3	10.5	3.9
	IV. Preliminary	Medium	226.9	74.2	165.4	15.34	5.49	25.37	9.08	72.9	11.2	4.0
	Experimental	"	411.1	127.4	279.0	15.82	5.95	44.13	16.61	67.9	10.7	4.0
	V. Preliminary	Low	200.0	35.5	142 8	15.77	5.87	22.52	8.38	71.4	11.3	4.2
	Experimental	"	387.5	63.7	258.8	16.00	6.00	41.40	15.54	66.8	10.7	4.0
	VI. Preliminary	Medium	250.9	68.5	150.6	16.06	6.12	24.19	9.21	60 0	9.6	3.7
	Experimental	"	446.5	123.2	284.3	15.78	5.86	44.87	16.65	63.7	10.0	3.7
RACHEL	II. Preliminary	No. 3 Medium	206.5	65.5	239.8	14.19	4.97	34.03	11.93	116.1	16.5	5.8
	Experimental	"	394.5	127.7	405.2	14.75	5.29	59.78	21.45	102.7	15.2	5.4
	III. Preliminary	High	255.8	102.5	223.2	15.57	5.73	34.73	12.80	87.3	13.6	5.0
	Experimental	"	450.4	181.7	407.5	15.40	5.64	62.78	22.99	90.5	13.9	5.1
	IV. Preliminary	Medium	22: 3	75.1	212.4	15.27	5.60	32.43	11.90	96.0	14.7	5.4
	Experimental	"	438.7	128.3	365.9	15.67	5.83	57.34	21.35	83.4	13.1	4.9
	V. Preliminary	Low	211.0	35.5	187.5	15.87	5.93	29 76	11.11	88.9	14.1	5 3
	Experimental	"	393.2	63.7	334.0	15.60	5.78	52.10	19.29	84.9	13 3	4.9
	VI. Preliminary	Medium	252.8	70.3	189.7	16.32	6.22	30.96	11.80	75.0	12.2	4.7
	Experimental	"	452.9	125.8	356.5	16.12	6.17	57.46	21.99	78.7	12.7	4.9
PUSSY WILLOW	III. Preliminary	No. 3 Medium	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	- --	- -
	Experimental	"	383.4	102.9	482.0	15.01	5.23	72.35	25.20	125.7	18.9	6.6
	IV. Preliminary	"	237.5	71.5	261.8	14.78	5.30	38.71	13.88	110.2	16.3	5.8
	Experimental	"	435.4	128.3	443.3	15.18	5.51	67 28	24.43	101 8	15.5	5.6
	V. Preliminary	Low	213 2	35.5	212.3	15.21	5.62	32.29	11.93	99.6	15.1	5.6
	Experimental	"	389.8	63.7	355.5	15.56	5 87	55.30	20.85	91.2	14.2	5.3
	VI. Preliminary	Medium	241.1	61.4	196.4	15.88	6.18	31.19	12.13	81.5	12.9	5.0
	Experimental	"	449.8	122.3	361.4	15.74	6.07	56 87	21.93	80.4	12.6	4.9

* In entire ration. † In experimental feed.

Name of cow	Adding single nutrients Period numbers	Experimental ration	Dry matter eaten *	Dry matter eaten †	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten					
										In entire ration			In experimental feed		
										Milk	Total solids	Fat	Milk	Total solids	Fat
			lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
CERES	I. Pre.	No. 1	262.2	69.0	248.1	14.88	5.48	36.91	13.58	94.6	14.1	5.2	359.5	53.5	19.7
	Exp.	"	483.0	123.8	463.3	14.68	5.41	68.02	25.09	95.9	14.1	5.2	374.3	55.0	20.3
	II. Pre.	oil	249.5	71.6	259.3	14.84	5.64	38.53	14.64	103.9	15.4	5.9	362.1	53.8	20.4
	Exp.	"	471.2	130.4	499.5	15.08	5.86	75.34	29.25	106.0	16.0	6 2	383.1	57.8	22.4
	III. Pre.	No. 1	266.0	69.6	266.0	15.04	5.59	40.00	14.86	100.0	15.0	5.6	382.1	57.5	21.3
	Exp.	"	468.8	125.9	475.0	15.18	5.60	72.09	26.58	101.3	15.4	5.7	377.4	57.3	21.1
	IV. Pre.	glu.	259.9	75.2	258.3	15.29	5.67	39.50	14.64	99.4	15.2	5.6	343.5	52.5	19.5
	Exp.	"	489.9	139.7	467.1	15.46	5.77	72.23	26.98	97 1	15.0	5.6	334.4	51.7	19.3
	V. Pre.	No. 1	260.9	69.8	226.6	15.70	5.98	35.57	13.55	86.9	13.6	5.2	324.7	51.0	19.4
	Exp.	"	480.6	123.1	407.0	15.69	6.03	63.84	24.56	84.7	13.3	5.1	330.7	51.9	20.0
	VI. Pre.	sugar	298.3	96.6	235.5	15.77	5.96	37.13	14.03	78.9	12 4	4.7	243.8	38.4	14.5
	Exp.	"	537.0	179.7	129.3	15.70	6.03	67.40	25.88	79.9	12.6	4.8	238.9	37.5	14.4
	VII. Pre.	No. 1	267.9	72.2	236.0	15.45	5.84	36.48	13.78	88.1	13.6	5.1	326.8	50.5	19.1
	Exp.	"	441.1	124.8	407.9	15.20	5.60	61.99	22.83	92.5	14.1	5.2	326.9	49.7	18.3
COWSLIP	I. Pre.	No. 1	233.9	64.6	215.0	14.47	5.16	31.11	11.10	91.9	13.3	4.7	332.8	48.2	17.2
	Exp.	"	403.8	114.3	366 4	14.35	5.09	52.57	18.64	90.7	13.0	4.6	320.6	46.0	16.3
	II. Pre.	glu.	214.5	69.3	200.3	14.43	5.16	28.90	10.34	93.4	13.5	4.8	289.0	41.7	14.9
	Exp.	"	409.4	133.7	366.5	15.07	5.50	55.24	20.15	89.5	13.5	4.9	274.2	41.3	15.1
	III. Pre.	No. 1	237.2	67.7	189 6	15.36	5.69	29.13	10.79	79.9	12.3	4.5	280.0	43.0	15.9
	Exp.	"	396.3	118.0	333 3	15.17	5.57	50.54	18.55	84.1	12.8	4.7	282.5	42.8	15.7
	IV. Pre.	sugar	238.6	87.4	187.5	15.16	5.47	28.42	10.25	78.6	11.9	4.3	214.6	32.5	11.7
	Exp.	"	433.2	166.8	311.6	15.04	5.49	46.85	17.11	71 9	10.8	3.9	186 8	28.1	10.3
	V. Pre.	No. 1	200.6	58.4	157.2	15.26	5 75	23.98	9.04	78 4	12.0	4.5	269.2	41.1	15.5
	Exp.	"	382.1	107.7	298.7	15.23	5.67	45.48	16.94	78.2	11.9	4.4	277.4	42.2	15.7
	VI. Pre.	oil	188 7	41.6	160.4	15.18	5.68	24.34	9.11	85.0	12.9	4.8	385.6	58.5	21.9
	Exp.	"	358.2	111.9	279.4	15.21	5.95	42.48	16.63	78.0	11.9	4.6	249.7	38.0	14.9
	VII. Pre.	No. 1	204.8	65.0	157.4	14.77	5.55	23.25	8.73	76.9	11.4	4.3	242.2	35.8	13.4
	Exp.	"	374.8	120.5	270 9	14.76	5.43	39 96	14.72	72.3	10.7	3.9	224.8	33.2	12.2
HAIDEE	II. Pre.	glu.	218.9	70.3	293.3	14.21	5.01	41.68	14.69	134.0	19.0	6.7	417.2	59.3	20.9
	Exp.	"	424.2	140.6	497.8	14.96	5.41	74.46	26.94	117.4	17.6	6.4	354.1	53.0	19.2
	III. Pre.	No. 1	235.1	69.6	259.3	15.30	5.58	39.68	14.47	110.3	16.9	6.2	372.5	57.0	20.8
	Exp.	"	411.3	125.9	435.2	15.31	5.49	66.61	23.89	105.8	16.2	5 8	345.7	52.9	19.0
	IV. Pre.	sugar	244.3	90.8	236.6	15.28	5.42	36.15	12.82	96.9	14.8	5.2	260.6	39.8	14.1
	Exp.	"	459.2	173.8	416.3	15.43	5.48	64.24	22.82	90.7	14.0	5.0	239.5	37.0	13.1
	V. Pre.	No. 1	233.1	69.8	216.8	15.85	5.84	34.37	12.66	93.0	14.7	5.4	310.5	49.2	18.1
	Exp.	"	441.0	123.1	381.9	16.10	6 09	61.47	23.26	86.6	13.9	5.3	310.3	50 0	18.9
	VI. Pre.	oil	237.5	58.0	210.2	16.07	6.24	33.78	13.12	88.5	14.2	5.5	362.4	58.2	22.6
	Exp.	"	439.6	114.6	406.9	16.09	6.27	65.48	25.50	92.6	14.9	5.8	355.1	57.2	22.3
	VII. Pre.	No. 1	253.7	69.4	218.8	15.55	5.85	34.02	12.81	86.3	13.4	5.0	315.2	49.0	18.5
	Exp.	"	413.8	124.8	369.8	15.39	5.72	56.92	21.17	89.4	13.8	5.1	296.3	45.6	17.0

* In entire ration. † In experimental feed.

Name of cow	Adding single nutrients	Experimental ration	Dry matter eaten *	Dry matter eaten †	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten					
										In entire ration			In experimental feed		
	Period numbers									Milk	Total solids	Fat	Milk	Total solids	Fat
			lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
LADYSMITH	I. Pre.	No. 1	247.3	60.4	244.9	14.61	4.86	35.79	11.91	99.0	14.5	4.8	405.5	59.3	19.7
	Exp.	“	426.7	97.1	413 3	14.50	4.89	59.92	20.20	96.9	14.0	4.7	425.7	61.7	20.8
	II. Pre.	sugar	253.2	92.9	208.1	14.98	5.06	31.17	10.52	82.2	12.3	4.2	224.0	33.6	11.3
	Exp.	“	479.9	172.4	430.7	15.04	5.06	64.77	21.79	89.7	13.5	4.5	249.8	37.6	12.6
	III. Pre.	No. 1	246.6	66.9	233.3	15 67	5.37	36.55	12.52	94.6	14.8	5.1	348.6	54.6	18.7
	Exp.	“	436.0	122.3	442.6	15.32	5.16	67.81	22.86	101.5	15.6	5.2	361.9	55.4	18.7
	IV. Pre.	oil	216.3	49.1	‡197.7	15.45	5.32	30.54	10.52	91.4	14.1	4.9	402.6	62.2	21.4
	Exp.	“	423.9	116.0	398.3	15.75	5.56	62.72	22.15	94.0	14.8	5.2	343.4	54.1	19.1
	V. Pre.	No. 1	242.7	68.9	207.7	15.42	5.23	32.02	10.87	85.6	13.2	4.5	301.5	46.5	15.8
	Exp.	“	448.0	122.3	328.5	16.03	5.50	52.66	18.06	73.3	11.8	4.0	268.6	43.1	14.8
	VI. Pre.	glu.	256.8	73.9	204.5	15.79	5.44	32.30	11.13	79.6	12.6	4.3	276.7	43.7	15.1
	Exp.	“	433.0	114.7	328.3	15.82	5.46	51.94	17.92	75.8	12.0	4.1	286.3	45.3	15.6
	VII. Pre.	No. 1	251.1	66.8	211.2	15.34	5.19	32.39	10.94	84.1	12.9	4.4	316.1	48.5	16.4
	Exp.	“	401.2	123.1	331.1	15.65	5.27	51.82	17.44	82.5	12.9	4.3	269 0	42.1	14.2
NAOMI	III. Pre.	No. 1	245.4	69.6	285.7	14.37	4.53	41.04	12.93	116.4	16.7	5.3	410.4	59.0	18.6
	Exp.	“	434.4	125.9	497.0	14.10	4.39	70.08	21.80	114.4	16.1	5.0	394.8	55.7	17.3
	IV. Pre.	oil	241.4	74.0	264.7	14.31	4 67	37.88	12.36	109.7	15.7	5.1	357.7	51.2	16.7
	Exp.	“	419.5	123.8	432.9	14.15	4.67	61.23	20.21	103.2	14.6	4.8	349.7	49.5	16.3
	V. Pre.	No. 1	239.9	69.8	234.3	13.92	4 44	32.61	10.39	97.7	13.6	4.3	335.6	46.7	14.9
	Exp.	“	436.1	123.1	420.8	14.08	4 51	59.27	18.98	96.5	13.6	4.4	341.9	48.2	15.4
	VI. Pre.	glu.	258.2	78.7	248.3	13.97	4.43	34.68	11.01	96.2	13.4	4.3	315.5	44.1	14.0
	Exp.	“	461.5	144.3	457.2	13.99	4.40	63.96	20.12	99.1	13.9	4.4	316.9	44.3	13 9
	VII. Pre.	No. 1	229.4	72.2	241.5	14.07	4.43	33.98	10.69	105 3	14.8	4.7	334.5	47.1	14.8
	Exp.	“	422.8	124.8	419.3	13.96	4.43	58.54	18.59	99.2	13.8	4.4	336.0	46.9	14.9
PAULINE	II. Pre.	sugar	-- --	-- --	-- --	-- --	- --	-- --	-- --	-- --	- --	- -	-- --	- --	- --
	Exp.	“	469.4	162.6	483.7	14.79	4.83	71.56	23.36	103.0	15.2	5.0	297.5	44.0	14.4
	III. Pre.	No. 1	246.7	69.6	276.0	14.79	4.89	40.82	13.49	111.9	16.5	5.5	396.5	58.6	19.4
	Exp.	“	435.6	125.9	469.5	14.31	4.66	67.17	21.90	107.8	15.4	5.0	372.9	53.4	17.4
	IV. Pre.	oil	241.9	74.0	253.3	14.58	4.92	36.92	12.47	104.7	15.3	5.2	342.3	49.9	16.9
	Exp.	“	445.0	136.4	445.2	14.83	5.29	66.01	23.53	100.0	14.8	5.3	326.4	48.4	17.3
	V. Pre.	No. 1	241.6	69.8	231.6	14.13	4.63	32.73	10 73	95.9	13.5	4.4	331.8	46.9	15.4
	Exp.	“	440.9	123.1	396.4	14.54	4.95	57.62	19.62	89.9	13.1	4.4	322.1	46.8	15.9
	VI. Pre.	glu.	259.9	78.7	236.0	14.27	4.71	33.68	11.12	90.8	13.0	4.3	299.9	42.8	14.1
	Exp.	“	403.1	140.0	410.1	13.92	4.51	57.10	18.48	101.7	14.2	4.6	292.9	40.8	13.2
	VII. Pre.	No. 1	212.9	70.3	225.4	14.13	4.72	31.83	10.64	105.9	15 0	5.0	320.6	45.3	15.1
	Exp.	“	419.0	124.8	388.4	13.88	4 48	53.90	17.41	92.7	12 9	4.2	311.2	43.2	14.0

* In entire ration. † In experimental feed.

‡ Sick.

Name of cow	Adding single nutrients	Nature of ration	Dry matter eaten *	Dry matter eaten †	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten					
										In entire ration			In experimental feed		
	Period numbers									Milk	Total solids	Fat	Milk	Total solids	Fat
			lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
PRETORIA	I. Pre.	No. 1	234.5	62.1	214.3	14.02	4.63	30.05	9.92	91.4	12.8	4.2	345.1	48.4	16.0
	Exp.	“	398.5	92.8	375.3	13.80	4.47	51.79	16.77	94.2	13.0	4 2	404.5	55.8	18.1
	II. Pre.	oil	202 3	59.4	205.0	13.90	4 72	28.51	9.67	101.3	14.1	4.8	345.1	48.0	16.3
	Exp.	“	387.2	116.2	355.5	14.51	5.07	51.57	18.02	91.8	13 3	4.7	306.0	44.4	15.5
	III. Pre.	No. 1	226.4	69.6	208.7	14.27	4.75	29.78	9.91	92.2	13.2	4.4	299.8	42.8	14.2
	Exp.	“	388.2	119.7	378.9	14.50	4.88	54.95	18.48	97.6	14.2	4.8	316.6	45.9	15.4
	IV. Pre.	glu.	219.0	72.5	205.9	14.56	4.80	29 98	9.89	94.0	13.7	4.5	284.1	41.4	13.6
	Exp.	“	408.9	137.9	371.7	14.62	4 99	54.34	18.55	90.9	13.3	4.5	269.6	39.4	13.5
	V. Pre.	No. 1	220.7	69.8	196.8	14.91	5.03	29.34	9.90	89.2	13.3	4.5	281.9	42.0	14.2
	Exp.	“	400.8	121.4	339.2	14.89	5.09	50.51	17.28	84.6	12.6	4.3	279.4	41.6	14 2
	VI. Pre.	sugar	243.5	89.4	203.6	14.68	4.97	29.88	10.11	83.6	12.3	4.2	227.7	33.4	11.3
	Exp.	“	455.9	175.2	353.9	14.74	4.99	52.16	17.67	77.6	11.4	3.9	202.0	29.8	10.1
	VII. Pre.	No. 1	229.7	67.7	197.7	14.54	4.89	28.75	9.67	86.1	12.5	4.2	292.0	42.5	14.3
	Exp.	“	414.3	122.2	347 1	14.29	4.82	49.60	16.72	83.8	12.0	4.0	284.1	40.6	13.7
PRISCILLA	I. Pre.	No. 1	----	----	----	----	----	----	----	----	----	----	----	----	----
	Exp.	“	433 8	123.8	403.5	14.96	5.22	60.37	21.05	93.0	13.9	4.9	326 0	48.8	17.0
	II. Pre.	glu.	232.4	70 3	205.4	14.80	5.15	30.39	10.58	88.4	13.1	4.6	292.1	43.2	15.0
	Exp.	“	450.2	140.6	354.7	15.24	5.40	54.06	19.22	78.8	12.0	4 3	252.3	38.5	13.7
	III. Pre.	No. 1	244.4	69.6	181.8	15.70	5.77	28.53	10 49	74.4	11.7	4.3	261.1	41.0	15.1
	Exp.	“	437.4	125.9	306.0	16.08	6.03	49.19	18.45	70.0	11.2	4.2	243.1	39.1	14.7
	IV. Pre.	sugar	258.5	90.0	160.2	16.08	6.11	25.76	9.79	62.0	10.0	3.8	178.0	28.6	10.9
	Exp.	“	479.5	173.8	274.1	16.17	6.06	44.31	16.60	57.2	9.2	3.5	157.7	25.5	9.6
	V. Pre.	No. 1	243.3	69.8	144.7	16 25	6.25	23.52	9.05	59.5	9.7	3.7	207.3	33.7	13.0
	Exp.	“	440.5	123.1	261.1	16.33	6.27	42.62	16.37	59.3	9.7	3.7	212.1	34.6	13.3
	VI. Pre.	oil	198.8	35.9	136.2	15.74	6.01	21.43	8.18	68 5	10.8	4.1	379 4	59.7	22.8
	Exp.	“	400.9	113.7	262.9	15.99	6 23	42.02	16.38	65.6	10.5	4.1	231.2	37.0	14.4
	VII. Pre.	No. 1	229.8	69.4	150.2	15.61	5.87	23.45	8.82	65.4	10.2	3.8	216.4	33.8	12.7
	Exp.	“	422.6	124.8	263.8	15.12	5.55	39.88	14.65	62.4	9.4	3.5	211.4	32.0	11.7
RUTH	I. Pre.	No. 1	246.4	69.0	186.6	13.63	4.47	25.43	8.34	75.7	10.3	3.4	270.4	36.9	12.1
	Exp.	“	453.2	123 8	321.9	13.48	4.32	43.38	13.93	71.0	9.6	3.1	260.0	35.0	11.3
	II. Pre.	oil	222.5	62.8	174.8	13 75	4.67	24.03	8.17	78.6	10.8	3.7	278.3	38.3	13.0
	Exp.	“	437.6	130.6	321.1	14.01	4.86	44.98	15.61	73.4	10.3	3.6	245 9	34.5	12.0
	III. Pre.	No. 1	247.6	69.6	173.6	13.64	4.32	23 68	7.50	70.1	9.6	3.0	249.4	34.0	10.8
	Exp.	“	422.9	125.9	284.5	13 92	4.46	39.59	12.70	67.3	9.4	3.0	226.0	31.4	10.1
	IV. Pre.	glu.	241.4	75.2	154 1	13.98	4.54	21.54	7.00	63.8	8.9	2.9	204.9	28.6	9.3
	Exp.	“	442.3	138.7	271.1	14.12	4.68	38.28	12.69	61.3	8.7	2.9	195.5	27.6	9.2
	V. Pre.	No. 1	238.8	69.8	137.4	14.22	4.80	19.54	6 60	57.5	8.2	2.8	196.8	28.0	9 5
	Exp.	“	429.9	123.1	253.9	14.19	4.80	36.02	12.18	59.1	8.4	2.8	206.3	29.3	9.9
	VI. Pre.	sugar	243.7	96.6	143.3	14.32	4.75	20.52	6.80	58.8	8.4	2.8	148 3	21.2	7.0
	Exp.	“	131.3	177.9	260.4	14.32	4.80	37.30	12.51	60.4	8.6	2.9	146.4	21.0	7.0
	VII. Pre.	No. 1	216.2	76.1	135.3	14.05	4.64	19.01	6.28	62.6	8.8	2.9	177.8	25.0	8.3
	Exp.	“	412.4	124.8	250.1	13.97	4.62	34.93	11.56	60.6	8.5	2.8	200.4	28.0	9.3
JERSEY LILY	III. Pre.	glu.	251.2	77.4	328.3	14.57	5.03	47.84	16.52	130.7	19.0	6.6	424.2	61.8	21.3
	Exp.	“	445.6	142.5	587.9	14.62	4.98	85.96	29.30	131 9	19.3	6.6	412.6	60.3	20.6
	IV. Pre.	No. 1	239.9	71.1	296.6	14.43	5.00	42.81	14 83	123.6	17.8	6.2	417.1	60.2	20.9
	Exp.	“	431.0	123.1	471.2	14.74	5.28	69.44	24.88	109.3	16.1	5.8	382.8	56.4	20.2
	V. Pre.	glu.	251.4	79.0	229.4	15.00	5.52	34.40	12.66	91.3	13.7	5.0	290.4	43.5	16.0
	Exp.	“	156.7	139.5	376.2	15.25	5.74	57.36	21.58	82.4	12.6	4.7	269.7	41.1	15.5
	VI. Pre.	No. 1	253.6	70.8	201.7	15.65	5.84	31.59	11.78	79.5	12.5	4.6	284.8	44.6	16.6
	Exp.	“	449.2	128.6	346.4	15.46	5.83	53.56	20.19	77.1	11.9	4.5	269.4	41.7	15.7
	VII. Pre.	glu.	249.1	77.3	186.6	15.65	5.99	29.20	11.18	74.9	11.7	4.5	241.4	37.8	14.5
	Exp.	“	441.7	139.7	323.7	15.38	5.84	49.80	18.92	73.3	11.3	4.3	231.7	35.7	13.5

* In entire ration. † In experimental feed.

Name of cow	Buckwheat middlings and Nos. 1 and 4 Period numbers	Nature of ration	Dry matter eaten *	Dry matter eaten †	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten					
										In entire ration			In experimental feed		
										Milk	Total solids	Fat	Milk	Total solids	Fat
			lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
IDARELLA	I. Pre.	B. M.	248.5	64.4	190.0	15.52	5 90	29.48	11.20	76.5	11.9	4.5	295 0	45.8	17.4
	Exp.	"	460.5	107.0	347.1	15.26	5.80	52.97	20.12	75.4	11.5	4.4	324.4	49.5	18.8
	II. Pre.	No. 1	241.2	68.6	191.2	15.07	5.66	28.80	10.82	79.3	11.9	4.5	278.7	42.0	15.8
	Exp.	"	460.9	124.0	342 8	15.30	5.72	52.44	19.61	74 4	11.4	4.3	276.5	42.3	15.8
	III. Pre.	B. M.	257.0	65.5	185.3	15.49	5.84	28.70	10.82	72.1	11.[illegible]	4.2	282.9	43.8	16.5
	Exp.	"	440.0	108.9	358.0	15.63	5.88	55.98	21.04	80.6	12.6	4.7	328.7	51.4	19.3
	IV. Pre.	No. 1	249.1	68.1	204.9	15.12	5.43	30.98	11.12	82.3	12.4	4.5	300-9	45.5	16.3
	Exp.	"	434 8	118.8	325.3	15 40	5.70	50.08	18.54	74.8	11.5	4.3	273.9	42.2	15.6
	V. Pre.	B. M.	249.1	62.4	179.5	15 52	5.89	27.86	10.58	72.1	11.2	4.2	287.7	44.6	17.0
	Exp.	"	465.0	116.6	319.5	15.61	5.95	49 89	19.02	68.7	10.7	4.1	274.1	42.8	16.3
	VI. Pre.	No. 1	269.7	70.9	187.3	15.51	5.72	29.06	10.71	69.5	10.8	4.0	264.1	41.0	15.1
	Exp.	"	480.8	127.7	360.3	15.26	5.60	54.98	20.17	74.9	11.4	4.2	282.2	43.1	15.8
SUENETTE	I. Pre.	No. 1	292.0	69.0	257.7	13.27	4.32	34.19	11.13	88.3	11.7	3.8	373.5	49.6	16.1
	Exp.	"	536.4	123.8	478 0	13.21	4 23	63.15	20.21	89.1	11.8	3.8	386.2	51.0	16.3
	II. Pre.	B. M.	294.4	70.8	257.4	13.44	4 41	34.58	11.36	93.8	12.6	4.1	363.5	48.8	16.0
	Exp.	"	510.8	122.1	452.7	13.49	4.48	61.06	20.28	88.6	12.0	4.0	370.8	50.0	16.6
	III. Pre.	No. 1	297.7	69.6	259 9	13.67	4.44	35.52	11.55	87.3	11.9	3.9	373.4	51.0	16.6
	Exp.	"	520.3	125.9	481.0	13.61	4.31	65 42	20.71	92.5	12.6	4.0	382.1	52.0	16.5
	IV. Pre.	B. M.	279.1	62.2	244 0	13 74	4.47	33.53	10.92	87.4	12.0	3.9	392.3	53.9	17.6
	Exp.	"	491.5	99.1	375.5	13.99	4.73	52.52	17.76	76.4	10.7	3.6	379 0	53.0	17.9
	V. Pre.	No. 1	289.5	69.9	203.5	14.03	4 67	28.55	9.51	70 3	9.9	3.3	291.1	40.8	13.6
	Exp.	"	536.2	123.[illegible]	373.2	14 10	4.73	52.63	17.64	69.6	9.8	3.3	303.2	42.8	14.3
	VI. Pre.	B. M.	285 4	52.3	186.3	14.50	5.05	27.01	9.37	65.3	9.5	3.3	356.2	51.6	17.9
	Exp.	"	531.7	108.2	337.3	14.25	4.87	48.07	16 44	63.4	9.0	3.1	311.8	44.4	15.2
	VII. Pre.	No. 1	295 7	68.7	176.4	14.17	4.81	24.97	8.48	59.7	8.4	2.9	256.7	36.3	12.3
	Exp.	"	491.3	124.8	299 4	14.18	4.75	42.46	14.23	60.9	8.6	2.9	239.9	34.0	11.4
BUTTERCUP	I. Pre.	B. M.	225.1	51.1	143.1	15.79	5.95	22.59	8.51	63.6	10.0	3.8	280.0	44.2	16.7
	Exp.	"	414.3	93.5	250.5	16.05	6.23	40.20	15.60	60.5	9.7	3.8	267.9	43.0	16.7
	II. Pre.	No. 4	217.2	54.2	135 0	15.62	5.82	21.08	7.85	62.1	9.7	3.6	249.1	38.9	14.5
	Exp.	"	409.6	96.3	234 0	16.10	6.23	37.67	14.57	57.1	9.2	3 6	243.0	39.1	15.1
	III. Pre.	B. M.	212.5	36.0	124.6	16.21	6 24	20.20	7.78	58.6	9.5	3.7	366.1	56.1	21.6
	Exp.	"	406 5	90 9	264.5	16.39	6.30	43.36	16.66	65.1	10.7	4.1	291.0	47.7	18.3
	IV. Pre.	No. 4	224.5	53 2	139.3	16.23	6.18	22.61	8.61	62.0	10.1	3.8	261.8	42.5	16.2
	Exp.	"	433.4	94.2	234.1	16 35	6 19	38.26	14.49	54.0	8.8	3.3	248.5	40 6	15.4
	V. Pre.	B. M.	229.3	39 9	121.4	16.56	6.40	20.11	7 77	52.9	8.8	3.4	304.3	50.4	19.5
	Exp.	"	426.9	67.2	230.1	16.78	6.74	38.60	15.51	53.9	9.0	3.6	342.4	57.4	23.1
	VI. Pre.	No. 4	250.1	53.3	132.6	16.68	6.50	22.12	8.62	53 0	8.8	3.4	248.7	41.5	16.2
	Exp.	"	455 5	93.3	235.1	16.44	6.39	38.65	15.03	51.6	8.5	3.3	252.0	41.4	16.1

* In entire ration. † In experimental feed.

Name of cow	Buckwheat middlings and No. 4; medium and wide rations	Experimental ration	Dry matter eaten *	Dry matter eaten †	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten					
										In entire ration			In experimental feed		
	Period numbers									Milk	Total solids	Fat	Milk	Total solids	Fat
			lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
SERENA	I. Pre.	No. 4	224.4	70.9	169.3	14.53	4.94	24.60	8.36	75.5	11.0	3.7	238.8	34.7	11.8
	Exp.	"	421.4	126.3	293.9	14.18	4.74	41.67	13.93	69.7	9.9	3.3	232.7	33.0	11.0
	II. Pre.	B. M.	218 9	70.1	177.1	14.61	5.16	25.88	9.14	80.9	11.8	4.2	252.6	36.9	13.0
	Exp.	"	390.3	104.1	308.4	14.78	5.26	45.58	16.23	79.0	11.7	4 2	296.3	43.8	15.6
	III. Pre.	No. 4	229.6	71.0	176.2	15.04	5.28	26.48	9.30	76.7	11.5	4.1	248.1	37.3	13.1
	Exp.	"	394.4	125.6	304.2	14.91	5.09	45.37	15.47	77.1	11.5	3.9	242.2	36.1	12.3
	IV. Pre.	B. M.	208.1	53.7	166.5	14.77	5.08	24.60	8.45	80.0	11.8	4.1	310.0	45.8	15.7
	Exp.	"	388.0	107.1	290.3	14.87	5.23	43.18	15.19	74 8	11.1	3.9	271.1	40.3	14.2
	V. Pre.	No. 4	225.6	69.0	154.8	15.18	5.41	23.50	8.38	68.6	10.4	3.7	224.3	34.1	12.1
	Exp.	"	417.4	126.4	274.2	15.08	5.27	41.35	14.45	65.7	9.9	3.5	216.9	32.7	11.4
DIME	IV. Pre.	No. 1	239.4	69.3	286.2	13.58	‡ 4.25	38.85	12.16	119.6	16.2	5.1	413.0	56.1	17.5
	Exp.	"	437.4	123.1	519.7	13.07	4 00	67.93	20.79	118.8	15.5	4.8	422.2	55.2	16.9
	V. Pre.	Q. D. F.	247.1	73.6	266.8	12.94	3.86	34.54	10.31	108.0	14.0	4.2	362.5	46.9	14.0
	Exp.	"	455.1	132.5	446 2	12.92	3.83	57.65	17.09	98.0	12.7	3.8	336.8	43.5	12.9
	VI. Pre.	No. 1	257.7	71.0	254.4	12.96	3.86	32.96	9.83	98.7	12.8	3.8	358.3	46.4	13.8
	Exp.	"	460.8	128.6	461.1	12.94	3.87	60.07	17.98	100.7	13.0	3.9	360.9	46.7	14.0
	VII. Pre.	Q. D. F.	253.4	71.6	250.6	12.84	3.69	32.16	9.24	98.9	12.7	3.6	349.9	44.9	12.9
	Exp.	"	440.6	130.7	430.8	12.62	3.65	54.35	15.72	97.8	12.3	3.6	329.6	41.6	12.0
EVA	II. Pre.	No. 1	242.0	68.5	186.5	17.03	7.01	31.76	13.08	77.1	13 1	5.4	272.3	46.4	19.1
	Exp.	"	457.5	124.0	322.9	17.42	7.12	56.24	22.99	70.6	12.3	5.0	260.4	45.4	18.5
	III. Pre.	Q. D. F.	254.5	66.1	181.8	17.32	7.03	31.48	12.78	71.4	12.4	5.0	275.0	47.6	19.3
	Exp.	"	465.3	124.2	327.6	17.63	7.17	57.75	23.50	70.4	12 4	5.1	263.8	46.5	18.9
	IV. Pre.	No. 1	251.9	69.3	181.0	17.69	7.26	32.01	13.14	71.9	12.7	5.2	261.1	46.2	19.0
	Exp.	"	449.5	123.1	312.5	17.68	7.28	55.26	22.75	69.5	12.3	5.1	253.9	44.9	18.5
	V. Pre.	Q. D. F.	254.0	69.9	161.4	18.12	7.56	29.25	12.20	63.5	11.5	4.8	230 8	41.8	17.5
	Exp.	"	259.7	119.6	283.6	17.99	7 51	51.01	21.27	61.7	11.1	4.6	237.1	42.7	17.8
	VI. Pre.	No. 1	255.6	69.0	171.5	18.09	7.60	31.02	13.03	67.1	12.1	5.1	248.5	45.0	18.9
	Exp.	"	458.4	128.6	323.9	17.75	7.34	57.50	23.76	70.7	12.5	5.2	251.9	44.7	18.5
	VII. Pre.	Q. D. F.	251.0	68.0	179.3	17.37	7.17	31.15	12.86	71.4	12 4	5.1	263 6	45.8	18.9
	Exp.	"	426.6	121.6	307.9	17.22	7.15	53.03	22.02	72.2	12.4	5.2	253 2	43.6	18.1
JIP	I. Pre.	No. 1	222.1	62.1	108.6	16.02	6.13	17.39	6.65	48.9	7.8	3.0	174.9	28.0	10.7
	Exp.	"	388.6	107.5	190.8	15.60	5 91	29.75	11.28	49.1	7.7	2.9	177.5	27.7	10 5
	II. Pre.	Q.D.F.	197.2	67.1	101.8	15.79	6 12	16.07	6.23	51.6	8.2	3.2	151.7	23.9	9.3
	Exp.	"	368.4	119.8	182.5	15.84	6.10	28 90	11.14	49.5	7.8	3.0	152.3	24.1	9.3
	III. Pre.	No. 1	213.4	69.9	102.0	15.93	6.05	16.24	6.17	47.8	7.6	2.9	145.9	23.2	8.8
	Exp.	"	360.9	124.1	191 9	15.99	6 06	30.68	11.63	53.2	8.5	3.2	154.6	24.7	9.4
	IV. Pre.	Q.D.F.	207.2	71.1	97.5	16.16	6.23	15.75	6.07	47.1	7.6	2.9	137.1	22.1	8.5
	Exp.	"	392.2	130.3	179.7	16.07	6.21	28.87	11.16	45.8	7.4	2.8	137.9	22.2	8 6
	V. Pre.	No. 1	215.8	69.2	101.8	16.27	6.28	16.57	6.39	47.2	7.7	3.0	147.1	23.9	9.2
	Exp.	"	396.4	123.1	175.3	16.19	6.31	28.38	11.07	44.2	7.2	2.8	142.4	23.1	9.0
	VI. Pre.	Q.D.F.	202.6	55 1	96.5	16.27	6 35	15.70	6.13	47.6	7.8	3.0	175.2	28.5	11.1
	Exp.	"	390.5	113.2	185.8	15.88	6.07	29.49	11.27	47.6	7.6	2.9	164.1	26 1	10.0

* In entire ration. † In experimental feed.

‡ Cowjust in ; milk shows colostral effect.

Name of cow	Medium and wide rations; equal balance	Experimental ration	Dry matter eaten *	Dry matter eaten †	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten					
										In entire ration			In experimental feed		
	Period numbers									Milk	Total solids	Fat	Milk	Total solids	Fat
			lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
MAX BELLE	I. Pre.	No. 1	242.2	69.0	128.6	16.95	6.71	21.79	8.65	53.1	9.0	3.6	186.3	31.6	12.5
	Exp.	"	449.9	123.8	228.1	16.39	6.26	37.38	14.27	50.7	8.3	3.2	184.2	30.2	11.5
	II. Pre.	Q.D.F.	226.3	70.5	117.8	16.20	6.32	19.08	7.45	52.1	8.4	3.3	167.1	27.1	10.6
	Exp.	"	443.7	132.8	201.2	17.08	6.81	34.36	13.69	45.3	7.7	3.1	151.5	25.9	10.3
	III. Pre.	No. 1	246.5	69.9	120.1	17.27	6.91	20.73	8.30	48.7	8.4	3.4	171.8	29.7	11.9
	Exp.	"	436.4	125.0	224.9	16.92	6.63	38.04	14.91	51.5	8.7	3.4	179.9	30.4	11.9
	IV. Pre.	Q.D.F.	239.2	72.1	110.4	17.25	6.96	19.04	7.68	46.2	8.0	3.2	153.1	26.4	10.7
	Exp.	"	439.8	132.1	206.7	17.21	6.86	35.57	14.18	47.0	8.1	3.2	156.5	26.9	10.7
	V. Pre.	No. 1	239.3	70.0	117.7	17.25	6.92	20.30	8.14	49.2	8.5	3.4	168.1	29.0	11.6
	Exp.	"	440.4	123.1	209.3	17.36	7.02	36.33	14.70	47.5	8.3	3.3	170.0	29.5	11.9
	VI. Pre.	Q.D.F.	239.3	68.0	119.6	17.37	6.98	20.77	8.35	50.0	8.7	3.5	175.8	30.5	12.3
	Exp.	"	405.9	127.9	203.5	17.33	7.08	35.33	14.44	50.2	8.7	3.6	159.4	27.6	11.3
	VII. Pre.	No. 1	218.5	68.4	115.8	17.36	7.19	20.10	8.32	53.0	9.2	3.8	169.4	29.4	12.2
	Exp.	"	410.0	124.8	198.2	16.99	6.87	33.67	13.62	48.3	8.2	3.3	158.8	27.0	10.9
MAIZIE	II. Pre.	No. 1	194.6	68.4	144.1	13.86	4.83	19.98	6.96	74.1	10.3	3.6	210.7	29.2	10.2
	Exp.	"	375.4	124.0	264.3	13.89	4.80	36.70	12.68	70.4	9.8	3.4	213.2	29.6	10.2
	III. Pre.	Q. D. F.	203.5	72.6	144.4	13.98	4.78	20.19	6.90	71.0	9.9	3.4	198.9	27.8	9.5
	Exp.	"	381.9	130.6	259.6	13.51	4.41	35.08	11.45	68.0	9.2	3.0	198.8	26.9	8.8
	IV. Pre.	No. 1	199.6	69.3	143.8	13.71	4.53	19.72	6.51	72.1	9.9	3.3	207.5	28.5	9.4
	Exp.	"	348.2	122.1	242.3	13.94	4.76	33.76	11.53	69.6	9.7	3.3	198.5	27.7	9.4
	V. Pre.	Q. D. F.	185.5	73.6	115.6	13.94	4.82	16.11	5.57	62.3	8.7	3.0	157.1	21.9	7.6
	Exp.	"	361.7	130.6	184.4	13.78	4.84	25.40	8.92	51.0	7.0	2.5	141.2	19.4	6.8
	VI. Pre.	No. 1	192.0	71.0	114.8	13.94	4.78	16.00	5.49	59.8	8.3	2.9	161.7	22.5	7.7
	Exp	"	330.6	128.6	209.0	13.97	4.85	29.20	10.14	63.2	8.8	3.1	162.5	22.7	7.9
	VII. Pre.	Q. D. F.	184.6	65.2	118.4	13.86	4.72	16.41	5.59	64.1	8.9	3.0	181.5	25.2	8.6
	Exp.	"	263.0	129.8	194.5	13.89	4.82	27.02	9.37	74.0	10.3	3.6	149.8	20.8	7.2
DANDELION	II. Pre	No. 4	226.6	71.1	124.8	16.05	6.48	20.03	8.09	55.1	8.8	3.6	175.5	2.82	11.4
	Exp	"	428.5	128.4	217.5	16.12	6.58	35.06	14.31	50.8	8.2	3.3	169.4	27.3	11.1
	III. Pre.	Q. D. F.	233.7	64.5	127.7	16.31	6.53	20.83	8.34	54.6	8.9	3.6	198.0	32.3	12.9
	Exp	"	401.8	101.2	229.9	16.23	6.40	37.31	14.71	57.2	9.3	3.7	227.2	36.9	14.5
	IV. Pre.	No. 4	232.1	68.5	134.6	16.07	6.31	21.63	8.50	58.0	9.3	3.7	196.5	31.6	12.4
	Exp.	"	415.8	124.7	232.1	16.44	6.55	38.15	15.21	55.8	9.2	3.7	186.1	30.6	12.2
	V. Pre.	Q. D. F.	208.4	45.9	116.5	16.56	6.70	19.29	7.81	55.9	9.3	3.7	253.8	42.0	17.0
	Exp.	"	376.2	81.9	198.5	16.56	6.70	32.87	13.29	52.8	8.7	3.5	242.4	40.1	16.2

* In entire ration. † In experimental feed.

Name of cow	Equal balance Period numbers	Experimental ration	Dry matter eaten *	Dry matter eaten †	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten					
										In entire ration			In experimental feed		
										Milk	Total solids	Fat	Milk	Total solids	Fat
			lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
FAIRIE	II. Pre.	No. 4	220.4	71.1	141.9	14.45	5.38	20.50	7.63	64.4	9.3	3.5	199.6	28.8	10.7
	Exp.	"	414.5	128.4	255.8	14.85	5.54	37.97	24.16	61.7	9.2	3.4	199.2	29.6	11.0
	III. Pre.	Q. D. F.	241.8	72.8	145.3	15.09	5.55	21.92	8.06	60.1	9.1	3.3	199.6	30.1	11.1
	Exp.	"	439.6	129.7	277.0	15.02	5.42	41.59	15.00	63.0	9.5	3.4	213.6	32.1	11.6
	IV. Pre.	No. 4	237.0	70.3	145.7	15.11	5.54	22.02	8.07	61.5	9.3	3.4	207.2	31.3	11.5
	Exp.	"	416.1	124.7	249.4	15.27	5.60	38.09	13.96	59.9	9.2	3.4	200.0	30.5	11.2
	V. Pre.	Q. D. F.	231.1	69.9	127.5	15.34	5.67	19.56	7.23	55.2	8.5	3.1	182.4	28.0	10.3
	Exp.	"	432.1	127.9	216.0	15.46	5.77	33.39	12.46	50.0	7.7	2.6	168.9	26.1	9.7
GOLDEN ROD	I. Pre.	No. 4	292.8	69.9	157.7	17.90	7.56	28.25	11.93	53.9	9.6	4.1	225.7	40.4	17.1
	Exp.	"	534.5	127.2	166.7	17.56	7.38	46.82	19.69	49.9	8.8	3.7	209.7	36.8	15.5
	II. Pre.	Q. D. F.	277.2	72.0	136.5	17.60	7.42	24.02	10.13	49.2	8.7	3.7	189.6	33.4	14.1
	Exp.	"	531.5	132.8	237.5	17.99	7.62	42.72	18.09	44.7	8.0	3.4	178.8	32.2	13.6
	III. Pre.	No. 4	295.9	71.2	127.0	18.34	7.90	23.29	10.03	42.9	7.9	3.4	178.4	32.7	14.1
	Exp.	"	524.4	125.6	222.3	18.44	7.93	41.00	17.63	42.4	7.8	3.3	177.0	32.7	14.0
	IV. Pre.	Q. D. F.	290.6	73.4	106.9	18.53	8.04	19.80	8.59	36.8	6.8	3.0	145.6	27.0	11.7
	Exp.	"	528.5	133.1	178.4	18.65	8.26	33.28	14.74	33.8	6.3	2.8	134.0	25.0	11.1
ROWENA	I. Pre.	No. 4	257.8	69.9	190.7	13.96	4.71	26.61	8.98	74.0	10.3	3.5	272.8	38.1	12.8
	Exp.	"	471.8	127.2	370.7	13.81	4.60	51.17	17.06	78.6	10.8	3.6	291.5	40.2	13.4
	II. Pre.	Q. D. F.	238.8	70.8	199.2	13.83	4.66	27.55	9.28	83.5	11.5	3.9	281.3	38.9	13.1
	Exp.	"	450.2	128.2	352.0	13.90	4.68	48.93	16.49	78.2	10.9	3.7	274.6	38.2	12.9
	III. Pre.	No. 4	250.1	70.3	194.6	14.32	4.84	27.87	9.41	77.8	11.1	3.8	276.8	39.6	13.4
	Exp.	"	454.8	123.8	367.4	14.24	4.74	52.31	17.43	80.8	11.5	3.8	296.6	42.3	14.1
	IV. Pre.	Q. D. F.	243.7	64.1	190.5	14.32	4.84	27.27	9.22	78.2	11.2	3.8	297.2	42.5	14.4
	Exp.	"	446.4	124.7	346.4	14.33	4.81	49.65	16.65	77.6	11.1	3.7	277.8	39.8	13.4
	V. Pre.	No. 4	251.0	68.2	185.4	14.66	4.99	27.17	9.26	73.9	10.8	3.7	271.8	39.8	13.6
	Exp.	"	464.7	126.4	304.1	14.46	4.90	43.98	14.90	65.4	9.5	3.2	240.6	34.8	11.8
	VI. Pre.	Q. D. F.	236.2	57.9	155.7	14.72	5.25	22.92	8.17	65.9	9.7	3.5	268.9	39.6	14.1
	Exp.	"	438.2	115.0	314.6	14.31	4.89	45.02	15.38	71.8	10.3	3.5	273.6	39.2	13.4
	VII. Pre.	No. 4	245.0	65.2	166.1	14.26	4.73	23.68	7.85	67.8	9.7	3.2	254.7	36.3	12.0
	Exp.	"	407.4	125.3	295.0	13.91	4.51	41.03	13.30	72.4	10.1	3.3	235.5	32.8	10.6
VIOLA	V. Pre.	Q. D. F.	219.8	70.2	161.5	15.50	‡ 5.57	25.03	8.99	73.5	11.4	4.1	230.0	35.7	12.8
	Exp.	"	402.3	127.9	292.0	15.02	5.22	43.85	15.25	72.6	10.9	3.8	228.3	34.3	11.9
	VI. Pre.	No. 4	232.7	71.0	161.6	15.00	5.15	24.24	8.32	69.5	10.4	3.6	227.6	34.1	11.7
	Exp.	"	418.4	124.4	275.4	14.67	5.06	40.38	13.93	65.8	9.7	3.3	221.4	32.5	11.2
	VII. Pre.	Q. D. F.	225.6	57.7	143.2	14.69	5.09	21.04	7.29	63.5	9.3	3.2	248.2	36.5	12.6
	Exp.	"	386.5	106.0	257.8	14.63	5.05	37.71	13.03	66.7	9.8	3.4	243.2	35.6	12.3

*** In entire ration. † In experimental feed. ‡ Cow just in; colostral effect.**

Name of cow	Grooming vs. non-grooming	Experimental ration	Dry matter eaten *	Dry matter eaten †	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten					
										In entire ration			In experimental feed		
	Period numbers									Milk	Total solids	Fat	Milk	Total solids	Fat
			lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
BETTIE	II. Pre.	Groomed	229.6	68.5	204.9	13.67	4.67	28.01	9.57	89.2	12.2	4.2	299.1	40.9	14.0
	Exp.	''	427.2	124.0	369.9	13.86	4.75	51.26	17.58	86.6	12.0	4.1	298.3	41.3	14.2
	III. Pre.	Not groom	242.1	69.6	203.9	14.26	4.95	29.08	10.09	84.2	12.0	4.2	293.0	41.8	14.5
	Exp.	''	438.0	125.9	415.4	14.30	4.84	49.40	20.11	94.8	13.6	4.6	330.0	47.2	16.0
	IV. Pre.	Groomed	239.3	68.3	225.2	14.01	4.78	31.55	10.77	94.1	13.2	4.5	329.7	46.2	15.8
	Exp.	''	452.9	123.1	395.2	14.26	4.88	56.34	19.28	87.3	12.4	4.3	321.1	45.8	15.7
	V. Pre.	Not groom	249.9	69.8	219.6	14.24	4.88	31.28	10.71	87.9	12.5	4.3	314.5	44.8	15.3
	Exp.	''	469.4	123.1	400.3	13.92	4.70	55.72	18.82	85.3	11.9	4.0	325.2	45.3	15.3
	VI. Pre.	Groomed	215.1	61.1	190.7	14.13	4.85	26.94	9.25	88.7	12.5	4.3	312.1	44.1	15.1
	Exp.	''	409.3	128.6	371.2	13.76	4.70	51.08	17.45	90.7	12.5	4.3	288.7	39.7	13.6
POLELA	IV. Pre.	Not griom	231.5	68.3	299.0	14.96	5.38	44.73	16.09	129.2	19.3	7.0	437.8	65.5	23.6
	Exp.	''	426.9	123.1	502.9	14.58	5.14	73.33	25.83	117.8	17.2	6.1	408.6	59.6	21.0
	V. Pre.	Groomed	239.3	69.8	251.6	14.57	5.13	36.65	12.91	105.1	15.3	5.4	360.4	52.5	18.5
	Exp.	''	444.2	123.1	428.8	14.51	5.24	62.23	22.48	96.5	14.0	5.1	348.4	50.6	18.3
	VI. Pre.	Not groom	252.8	70.8	232.7	14.59	5.18	33.94	12.06	92.0	13.4	4.8	328.6	47.9	17.0
	Exp.	''	461.1	128.6	413.0	14.72	5.32	60.77	21.95	89.6	13.2	4.8	321.2	47.3	17.1
	VII. Pre.	Groomed	257.3	70.3	228.6	14.76	5.32	33.74	12.16	88.9	13.1	4.7	325.1	48.0	17.3
	Exp.	''	475.2	124.8	402.3	14.59	5.17	58.70	20.79	84.7	12.4	4.4	322.4	47.0	16.7
SALIDA	IV. Pre.	Not groom	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	--	-- --	-- --	-- --
	Exp.	''	399.0	119.5	454.2	15.17	5.20	68.88	23.59	113.8	17.3	5.9	380.1	57.6	19.7
	V. Pre.	Groomed	235.8	69.8	235.2	14.87	5.08	34.98	11.96	99.7	14.8	5.1	336.9	50.1	17.1
	Exp.	''	446.5	123.1	386.0	14.58	4.89	56.27	18.87	86.5	12.6	4.2	313.6	45.7	15.3
	VI. Pre.	Not groom	255.2	70.8	208.1	14.61	4.88	30.41	10.16	81.5	11.9	4.0	293.9	42.9	14.3
	Exp.	''	460.2	128.6	352.1	14.72	5.05	51.81	17.77	76.5	11.3	3.9	273.8	40.3	13.8
	VII. Pre.	Groomed	255.2	70.3	181.3	14.88	5.28	26.98	9.58	71.0	10.6	3.8	257.8	38.4	13.6
	Exp.	''	440.8	124.8	316.6	14.54	4.97	46.03	15.72	71.8	10.4	3.6	253.7	36.9	12.6

*** In entire ration. † In experimental feed.**

Name of cow	Watering at will and at intervals	Manner of giving water	Dry matter eaten *	Dry matter eaten †	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten					
										In entire ration			In experimental feed		
	Period numbers									Milk	Total solids	Fat	Milk	Total solids	Fat
			lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
FLORA	V. Pre.	will	243.1	69.8	394.0	13.17	4.32	51.87	17.01	162.1	21.3	7.0	564.4	74.3	24.4
	Exp.	"	463.8	123.1	691.3	13.38	4.41	92.49	30.48	149.1	19.9	6.6	561.6	75.1	24.8
	VI. Pre.	int	260.2	70.8	362.3	13.64	4.60	49.43	16.66	139.3	19.0	6.4	511.7	69.8	23.5
	Exp.	"	457.9	128.6	647.3	13.55	4.53	87.76	29.36	141.4	19.2	6.4	503.3	68.2	22.8
	VII. Pre.	will	247.8	70.3	352.1	13.66	4.67	48.11	16.46	142.1	19.4	6.6	500.8	68.4	23.4
	Exp.	"	403.0	124.8	592.7	13.27	4.40	78.67	26.07	147.1	19.5	6.5	475.0	63.0	20.9
L'Y PERUSIA	V. Pre.	will	244.5	69.8	261.2	14.86	5.35	38.81	13.97	106.8	15.9	5.7	374.1	55.6	20.0
	Exp.	"	450.3	123.1	440.5	14.93	5.35	65.76	23.57	97.8	14.6	5.2	357.9	53.4	19.2
	VI. Pre.	int	257.5	70.8	249.3	15.13	5.45	37.71	13.58	96.8	14.6	5.3	352.1	53.3	19.2
	Exp.	"	465.6	128.6	455.7	15.19	5.57	69.20	25.37	97.9	14.9	5.4	354.4	53.8	19.7
	VII. Pre.	will	258.3	70.3	256.9	15.12	5.50	38.85	14.14	99.5	15.0	5.5	365.4	55.3	20.1
	Exp.	"	456.2	124.8	437.6	15.22	5.54	66.59	24.25	95.9	14.6	5.3	350.7	53.4	19.4
MAX ELLA	IV. Pre.	will	250.0	68.3	322.1	14.20	4.65	45.74	14.98	128.8	18.3	6.0	471.6	67.0	21.8
	Exp.	"	451.1	123.1	546.7	14.13	5.68	77.26	25.61	121.2	17.1	5.7	444.1	62.8	22.9
	V. Pre.	int	255.4	69.8	296.3	14.15	4.75	41.94	14.08	116.0	16.4	5.5	424.5	60.1	20.7
	Exp.	"	369.8	123.1	504.8	14.54	5.04	73.38	25.43	107.4	15.6	5.4	410.1	59.6	20.4
	VI. Pre.	will	268.5	70.8	273.4	14.46	5.03	39.52	13.74	101.8	14.7	5.1	386.1	55.8	10.6
	Exp.	"	478.8	126.8	487.3	14.30	4.83	69.69	23.52	101.8	14.6	4.9	384.4	55.0	19.5
	VII. Pre.	int	262.6	70.3	268.9	14.22	4.84	38.24	13.02	102.4	14.6	5.0	382.5	54.4	18.3
	Exp.	"	429.0	124.8	460.8	13.86	4.68	63.85	21.55	107.4	14.9	5.0	369.2	51.2	18.7
M. BELLA	V. Pre.	int	241.4	69.8	320.4	14.31	4.95	45.86	15.86	132.7	19.0	6.6	459.0	65.7	22.7
	Exp.	"	445.7	123.1	560.9	14.56	5.23	81.67	29.31	125.9	18.3	6.6	455.8	66.3	23.8
	VI. Pre.	will	257.5	70.8	308.0	14.60	5.29	44.97	16.30	119.6	17.5	6.3	435.0	63.5	23.0
	Exp.	"	456.9	128.6	529.8	14.66	5.37	77.68	28.46	116.0	17.0	6.2	412.0	60.4	22.1
	VII. Pre.	int	256.4	70.3	284.4	14.81	5.44	42.12	15.48	110.9	16.4	6.0	404.5	59.9	22.0
	Exp.	"	429.6	124.8	486.2	14.70	5.43	71.50	26.39	113.2	16.6	6.1	389.6	57.3	21.1
ATALANTA	I. Pre.	warm'd	258.1	69.0	170.7	12.46	3.80	21.27	6.49	66.1	8.2	2.5	247.3	30.8	9.4
	Exp.	"	472.4	123.8	291.6	12.30	3.79	35.87	11.05	61.7	7.6	2.3	235.6	29.0	8.9
	II. Pre.	cold	239.8	68.5	159.9	12.22	3.70	19.54	5.91	66.7	8.1	2.5	233.4	28.5	8.6
	Exp.	"	455.1	124.0	290.7	12.41	3.83	36.09	11.12	63.9	7.9	2.4	234.4	29.1	9.0
	III. Pre.	warm'd	256.8	69.6	152.5	12.73	3.95	19.42	6.02	59.4	7.6	2.3	211.9	27.9	8.6
	Exp.	"	456.1	125.9	266.8	12.63	3.85	33.68	10.26	58.5	7.4	2.2	212.0	26.8	8.2
	IV. Pre.	cold	247.6	68.3	142.6	12.60	3.75	17.96	5.35	57.6	7.3	2.2	208.7	26.3	7.8
	Exp.	"	455.0	123.1	238.0	12.74	3.90	30.32	9.28	52.3	6.7	2.0	193.4	24.6	7.5
	V. Pre.	warm'd	252.6	69.8	120.5	12.75	3.96	15.36	4.77	47.7	6.1	1.9	172.6	22.0	6.8
	Exp.	"	463.1	123.1	181.3	12.71	3.96	23.04	7.18	39.2	5.0	1.6	147.3	18.7	5.8
	VI. Pre.	cold	257.6	69.0	90.7	13.10	4.19	11.88	3.80	35.2	4.6	1.5	131.4	17.2	5.5
	Exp.	"	442.9	123.2	146.8	13.10	4.31	19.23	6.32	33.1	4.3	1.4	119.2	15.6	5.1

* In entire ration. † In experimental feed.

Name of cow	Warm and cold water	Manner of giving water	Dry matter eaten *	Dry matter eaten †	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten					
										In entire ration			In experimental feed		
	Period numbers									Milk	Total solids	Fat	Milk	Total solids	Fat
			lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
CLARE	I. Pre.	warm'd	296.1	69.0	179.0	14.84	5.51	26.56	9.87	60.5	9.0	3.3	259.4	38.5	14.3
	Exp.	"	541.7	123.8	332.1	14.71	5.36	48.87	17.81	61.3	9.0	3.3	268.3	39.5	14.4
	II. Pre.	cold	278.9	68.5	176.1	14.63	5.28	25.77	9.30	63.1	9.2	3.3	257.0	37.6	13.6
	Exp.	"	529.4	124.0	307.7	14.94	5.51	45.96	16.95	58.1	8.7	3.2	248.2	37.1	13.7
	III. Pre.	warm'd	301.2	69.6	166.3	15.12	5.53	25.14	9.20	55.2	8.3	3.1	238.9	36.1	13.2
	Exp.	"	524.9	125.9	300.3	14.95	5.34	44.90	16.05	57.2	8.6	3.1	238.6	35.7	12.8
	IV. Pre.	cold	285.5	68.3	155.1	14.99	5.41	23.25	8.39	54.3	8.1	2.9	227.0	34.0	12.3
	Exp	"	520.8	123.1	227.8	15.20	5.55	34.62	12.65	43.7	6.6	2.4	185.1	28.1	10.3
EDNA	I. Pre.	warm'd	250.7	69.0	182.0	14.91	5.15	27.14	9.38	72.6	10.8	3.7	263.7	39.3	13.6
	Exp.	"	469.0	120.4	293.8	14.64	5.14	43.00	15.10	62.6	9.2	3.2	244.0	35.7	12.5
	II. Pre.	cold	244.0	68.5	162.7	14.30	4.86	23.26	7.91	56.7	9.5	3.2	237.5	33.9	11.5
	Exp.	"	468.4	124.0	291.3	14.90	5.27	43.40	15.36	62.2	9.3	3.3	234.9	35.0	12.4
	III. Pre.	warm'd	265.5	69.6	150.4	14.93	5.27	22.45	7.93	56.7	8.5	3.0	216.1	32.3	11.4
	Exp.	"	462.0	125.9	260.9	14.93	5.18	38.94	13.51	56.5	8.4	2.9	207.2	30.9	10.7
	IV. Pre.	cold	252.5	68.3	131.8	14.85	5.15	19.57	6.79	52.2	7.8	2.7	192.9	28.6	9.9
	Exp.	"	461.6	123.1	222.9	14.80	5.23	32.99	11.65	48.3	7.1	2.5	181.1	26.8	9.5
	V. Pre.	warm'd	255.0	68.0	116.2	14.72	5.19	17.10	6.05	45.6	6.7	2.4	170.8	25.1	8.9
	Exp.	"	473.9	123.1	215.7	14.80	5.20	31.91	11.21	45.5	6.7	2.4	175.3	25.9	9.1
	VI. Pre.	cold	270.8	70.8	130.2	14.71	5.16	19.15	6.71	48.1	7.1	2.5	183.9	27.0	9.5
	Exp.	"	475.2	126.8	234.7	14.68	5.20	34.44	12.21	49.4	7.2	2.6	185.1	27.2	9.6
	VII. Pre.	warm'd	249.6	68.6	136.2	14.28	4.90	19.47	6.68	54.6	7.8	2.7	198.7	28.4	9.7
	Exp.	"	415.8	124.8	215.5	14.46	5.04	31.17	10.86	51.8	7.5	2.6	172.7	25.0	8.7
ORPHA	II. Pre.	warm'd	182.1	57.2	113.2	14.59	5.12	16.52	5.80	62.2	9.1	3.2	197.9	28.9	10.1
	Exp.	"	384.5	124.0	254.7	14.55	4.85	37.06	12.36	66.2	9.6	3.2	205.4	29.9	10.0
	III. Pre.	cold	270.8	68.6	139.1	14.40	4.59	20.02	6.39	51.4	7.4	2.4	202.7	29.2	9.3
	Exp.	"	389.9	125.9	261.0	14.15	4.46	36.93	11.65	66.9	9.5	3.0	207.3	29.3	9.3
	IV. Pre.	warm'd	214.0	68.3	143.9	14.04	4.32	20.20	6.22	67.2	9.4	2.9	210.6	29.6	9.1
	Exp.	"	387.1	123.1	247.8	14.10	4.44	34.94	11.01	64.0	9.0	2.8	201.3	28.4	8.9
	V. Pre.	cold	216.9	69.8	124.4	14.23	4.56	17.70	5.67	57.4	8.2	2.6	178.2	25.4	8.1
	Exp.	"	396.9	123.1	206.1	15.15	4.66	29.15	9.60	51.9	7.3	2.4	167.4	23.7	7.8
	VI. Pre.	warm'd	222.5	69.9	118.7	14.37	4.83	17.07	5.73	53.3	7.7	2.6	169.8	24.4	8.2
	Exp.	"	405.2	127.7	212.8	14.36	4.79	30.56	10.19	52.5	7.5	2.5	166.7	23.9	8.0
	VII. Pre.	cold	216.6	69.4	115.8	14.40	4.84	16.68	5.60	53.5	7.7	2.6	166.8	24.0	8.1
	Exp.	"	370.7	124.8	200.8	14.25	4.61	28.64	19.26	54.2	7.7	2.5	160.9	23.0	7.4
RED TOP	I. Pre.	cold	259.9	69.0	217.5	13.15	4.36	28.59	9.49	83.7	11.0	3.7	315.1	41.4	13.8
	Exp.	"	477.1	123.8	383.1	13.10	4.34	50.18	16.61	80.3	10.5	3.5	309.5	40.5	13.4
	II. Pre.	warm'd	239.8	68.5	177.9	13.38	4.37	23.80	7.77	74.2	9.9	3.2	259.6	34.7	11.3
	Exp.	"	459.1	123.1	281.4	13.89	4.55	39.09	12.80	61.3	8.5	2.8	228.6	31.8	10.4
	III. Pre.	cold	261.2	69.6	124.0	14.23	4.74	17.65	5.88	47.5	6.8	2.3	178.1	25.4	8.4
	Exp.	"	459.4	123.2	199.5	14.24	4.62	28.40	9.21	43.4	6.2	2.0	161.9	23.1	7.5
SYLVIA	I. Pre.	cold	262.1	69.0	224.9	14.18	4.74	31.89	10.65	85.8	12.2	4.1	325.9	46.2	15.4
	Exp.	"	477.2	123.8	398.7	14.13	4.68	56.35	18.67	83.6	11.8	3.9	322.1	45.5	15.1
	II. Pre.	warm'd	242.6	68.5	213.3	14.16	4.78	30.21	10.19	87.9	12.5	4.2	311.3	44.1	14.9
	Exp.	"	462.3	124.0	380.7	14.58	5.00	55.48	19.04	82.3	12.0	4.1	307.1	44.8	15.4
	III. Pre.	cold	262.9	69.6	212.2	14.63	4.99	31.04	10.60	80.7	11.8	4.0	304.9	44.6	15.2
	Exp.	"	467.0	125.9	405.9	14.90	5.01	60.47	20.34	86.9	12.9	4.4	322.4	48.0	16.2
	IV. Pre.	warm'd	253.0	68.3	190.2	15.64	5.42	29.74	10.31	75.2	11.8	4.1	278.5	43.5	15.1
	Exp.	"	466.9	123.1	297.5	16.01	5.59	47.61	16.62	63.7	10.2	3.6	241.7	38.7	13.5
	V. Pre.	cold	261.8	69.8	149.7	15.98	5.60	23.94	8.39	57.2	9.1	3.2	214.4	34.3	12.0
	Exp.	"	481.8	123.1	281.7	15.93	5.65	44.88	15.91	58.5	9.3	3.3	228.9	36.5	12.9
	VI. Pre.	warm'd	272.8	70.8	161.9	15.61	5.57	25.28	9.02	59.4	9.3	3.3	228.6	35.7	12.7
	Exp.	"	475.3	128.6	274.1	15.44	5.47	42.32	14.98	57.7	8.9	3.2	213.1	32.9	11.6

* In entire ration. † In experimental feed.

VI. DIFFERENCE TABLES.[1] (*a*) TOTALS OF DIFFERENCES; (*b*) PERCENTAGE DIFFERENCES.

(Showing differences in experimental feeding between the average of the results of two periods on one ration and those actually obtained with another ration in the intervening period.)

(*a*) TOTALS OF DIFFERENCES

Rations	Periods represented	Total dry matter eaten	Dry matter eaten in experimental feed	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter					
									In entire ration			In experimental feed		
									Milk	Total solids	Fat	Milk	Total solids	Fat
		lbs	lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs
Low to high	4	+404.0	+480.0	+190.6	+1.69	+0.89	+36.15	+14.31	−34 2	−3.6	−0.9	---- --	--- --	-- ---
High to low	4	−363.7	−476.8	−365.7	+0.92	+1.08	−46.59	−12.65	− 9.1	−0.2	+0.9	---- --	--- --	-- ---
Low to medium	5	+263.7	+304 8	+ 85.5	+1.32	+1.14	+17.70	+ 9.12	−36.6	−4.2	−0.8	---- --	--- --	-- ---
Medium to low	9	−515 2	−558.6	−362.9	−0.86	−0.68	−53.87	−20.40	+30.8	+3.6	+1.0	---- --	--- --	-- ---
Medium to high	10	+350.5	+471.0	+311.6	+1.13	−0.25	+50.00	+14.83	+ 1.4	+0.7	−0.4	---- --	--- --	-- ---
High to medium	5	−194.2	−265.9	−216.8	+0.82	+1.01	−26.75	− 6.17	−10.2	−0.5	+0.5	---- --	--- --	-- ---
Medium to medium	8	− 61.7	− 16.1	−134.3	+1.33	+0.81	−13.95	− 3.79	−24.1	−2.5	−0.8	− 64.3	− 5.6	− 1.5
I + gluten (act) ± I (calc)	9	+ 73.9	+ 97.1	+106.8	−0.17	−0.23	+15.37	+ 4.75	+10.1	+1.4	+0.4	−138.2	−20.2	− 7.1
I + sugar (act) ± I (calc)	7	+300.2	+378.2	+ 37 4	+0.30	−0.17	+ 6.74	+ 1.55	−46.6	−7.1	−2.6	−622.3	−93.5	−34.0
I + palm oil (act) ± I (calc)	9	− 77.4	+ 4.1	+ 51.5	+2.17	+3.22	+16.42	+15.32	+24.9	+5.7	+4.4	+ 13.6	+10.5	+11.8
IV (act) ± B. M. (calc)	4	+ 32.6	+ 56.7	+ 60.4	−0.52	−0.71	+ 6.06	− 0.23	+ 6.2	+0 4	−0.2	−112.6	−18.5	− 8.5
B. M. (act) ± I (calc)	5	− 33.2	− 63.2	− 76.8	+0.89	+1.02	− 7.14	+ 0.52	− 9.0	−0 5	+0.3	+112.6	+19.5	+ 9.3
IV (act) ± B. M. (calc)	4	+ 56.9	+ 52.6	− 40.4	−0.05	−0.49	− 6.46	− 3.74	−19.6	−3.1	−1.5	−180.7	−28.7	−12.1
B. M. (act) ± IV (calc)	5	−111.9	− 79.3	+ 35.4	+0.66	+1.08	+ 7.34	+ 4.99	+27.1	+4.6	+2.3	+250.6	+41.3	+17.7
I (act) ± Q. D. F. (calc)	9	+ 7.4	− 18.0	+128.6	+0.70	+0.14	+21.88	+ 8.06	+28.0	+4.9	+1.8	+122.1	+19.8	+ 7.2
Q. D. F. (act) ± I (calc)	10	+ 55.6	+ 44.4	−153.8	+0.33	+0.37	−22.57	− 8.00	−47.9	−7.1	−2.4	−188.9	−26.8	− 9.7
IV (act) ± Q. D. F. (calc)	6	+ 54.3	+ 32.8	+ 27.4	+0.29	−0.05	+ 5.92	+ 2.18	−29.5	+0.1	+0.1	− 48.4	− 6.3	− 2.5
Q. D. F. (act) ± I (calc)	6	− 18.5	− 24.5	+ 31.0	−0.13	−0.18	+ 4.27	+ 1.32	+10.5	+1.5	+0.5	+ 74.0	+10.9	+ 4.0
No gr. (act) ± gr. (calc)	4	+ 54.1	+ 8.7	+ 48.1	+0.47	+0.16	+ 8.57	+ 2.91	+ 0.4	+0.7	+0.1	+ 16.5	+ 3.6	+ 1.2
Gr. (act) ± no gr. (calc)	3	+ 16.3	− 5.2	− 59.1	−0.36	−0.12	−10.12	− 3.41	−18.7	−3.3	−1.1	− 36.4	− 6.7	− 2.2
Will (act) ± int. (calc)	2	+ 48.6	+ 7.4	+ 10.7	+0.13	+0.01	+ 2.16	+ 0.64	− 9.2	−1.2	−0.5	− 16.0	− 1.8	− 0.8
Intervals (act) ± will (calc)	3	+ 41.6	+ 7.3	+ 9.7	+0.65	+0.52	+ 5.10	+ 3.40	− 9.8	−0.5	+0.1	− 19.1	+ 0.2	+ 1.3
Cold (act) ± warmed (calc)	10	+ 27.0	− 1.5	+ 82.7	−0.25	+0.07	+11.39	+ 4.14	+13.7	+1.8	+0.7	+ 66.0	+ 8.9	+ 3.5
Warmed (act) ± cold (calc)	10	+ 4.0	+ 4.5	− 39.7	+0.84	+0.06	− 2.37	− 0.98	− 7.4	−0.3	−0.1	− 37.5	− 2.7	− 1.1

(*b*) PERCENTAGE DIFFERENCES

Rations	Periods represented	Total dry matter eaten	Dry matter eaten in experimental feed	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter					
									In entire ration			In experimental feed		
									Milk	Total solids	Fat	Milk	Total solids	Fat
		lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
Low to high	4	+ 25	+ 186	+ 13	+ 4	+ 5	+ 17	+ 19	− 9	− 9	− 5	------	------	------
High to low	4	− 20	− 66	− 20	+ 2	+ 6	− 19	− 15	− 1	− 1	+ 5	------	------	------
Low to medium	5	+ 13	+ 92	+ 4	+ 2	+ 6	+ 6	+ 10	− 8	− 6	− 3	------	------	------
Medium to low	9	− 13	− 50	− 10	− 1	− 2	− 10	− 10	+ 4	+ 3	+ 2	------	------	------
Medium to high	10	+ 8	+ 38	+ 8	+ 1	− 1	+ 9	+ 7	0	+ 1	− 1	------	-----	------
High to medium	5	− 8	− 30	− 10	+ 1	+ 4	− 9	− 6	− 2	− 1	+ 2	------	------	------
Medium to medium	8	− 2	− 2	− 4	+ 1	+ 2	− 3	− 3	− 3	− 2	− 2	− 2	− 1	− 1
I + gluten (act) ± I (calc)	9	+ 2	+ 9	+ 3	0	0	+ 3	+ 3	+ 1	+ 1	+ 1	− 5	− 5	− 5
I + sugar (act) ± I (calc)	7	+ 10	+ 45	+ 2	0	0	+ 2	1	− 8	− 8	− 8	− 30	− 30	− 31
I + oil (act) ± I (calc)	9	− 2	0	+ 2	+ 2	+ 7	+ 3	+ 9	+ 3	+ 5	+ 11	0	+ 2	+ 8
I (act) ± B. M (calc)	4	+ 2	+ 13	+ 4	− 1	− 3	+ 3	0	+ 2	+ 1	− 1	− 8	− 9	− 12
B. M. (act) ± I (calc)	5	− 1	− 10	− 4	+ 1	+ 4	− 3	+ 1	− 2	− 1	+ 2	+ 7	+ 9	+ 12
IV (act) ± B. M. (calc	4	+ 4	+ 13	− 4	0	− 2	− 4	− 1	− 7	− 7	− 9	− 16	− 16	− 18
B. M. (act) ± IV (calc)	5	− 5	− 14	+ 3	+ 1	+ 4	+ 4	+ 7	+ 8	+ 9	+ 13	+ 21	+ 23	+ 27
I (act) ± Q. D. F. (calc)	9	0	− 2	+ 6	0	0	+ 6	+ 6	+ 5	+ 6	+ 6	+ 7	+ 7	+ 7
Q. D. F. (act) ± I (calc)	10	+ 1	+ 4	− 6	0	+ 1	− 5	− 5	− 8	− 7	− 6	− 9	− 8	− 8
IV (act) ± Q. D. F. (calc)	6	+ 2	+ 4	+ 2	0	0	+ 2	+ 2	− 1	0	0	− 4	− 3	− 3
Q. D. F. (act) ±IV (calc)	6	− 1	− 3	+ 2	0	− 1	+ 2	+ 1	+ 3	+ 3	+ 2	+ 6	+ 5	+ 5
No gr. (act) ± gr. (calc)	4	+ 3	+ 2	+ 3	+ 1	+ 1	+ 4	+ 4	0	+ 1	+ 1	+ 1	+ 2	+ 2
Gr. (act) ± No gr. (calc)	3	+ 1	− 1	− 6	− 1	− 1	− 6	− 5	− 6	− 8	− 7	− 4	− 5	− 4
Will (act) ± int. (calc)	2	+ 5	+ 3	+ 1	0	0	+ 1	+ 1	− 4	− 4	− 4	− 2	− 2	− 2
Int. (act) ± will (calc)	3	+ 3	+ 2	+ 1	+ 2	+ 4	+ 2	+ 4	− 3	− 1	+ 1	− 1	0	+ 2
Cold (act) ± warmed (calc)	10	+ 1	0	+ 3	0	0	+ 3	+ 3	+ 2	+ 2	+ 2	+ 3	+ 3	+ 3
Warmed (act) ± cold (calc)	10	0	0	− 1	+ 1	0	− 1	− 1	− 1	0	0	− 2	− 1	− 1

VII. RESULTS OF EXPERIMENTAL FEEDING ON DIFFERENT RATIONS

LOW AND MEDIUM GRAIN FEEDING

Rations	Total dry matter eaten	Dry matter eaten in experimental feed	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter in entire ration			Ratio of percent of fat to percent of solids-not-fat
								Milk	Total solids	Fat	
GRAIN RATION NO. 1. 144 days' feeding on each ration											
	lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	1 :
Low	3468	495	3380	13.47	4.46	448.9	146.7	97.4	13.0	4.3	2.02
Medium	3885	995	3653	13.53	4.54	486.3	161.3	94.0	12.6	4.2	1.98
Medium ± low	+ 417	+ 500	+ 273	+0.06	+0.08	+37.4	+14.6	− 3.4	− 0.4	− 0.1	− 0.04
Percentage differences	+ 12	+ 101	+ 8	0	+ 2	+ 8	+ 10	− 4	− 3	− 2	− 2
GRAIN RATION NO. 2. 108 days feeding on each ration											
Low	2296	387	1996	14.60	5.11	290.6	101.2	85.8	12.5	4.4	1.86
Medium	2629	742	2175	14.79	5.21	322.3	113.8	81.9	12.1	4.3	1.84
Medium ± low	+ 333	+ 355	+ 179	+0.19	+0.10	+31.7	+12.6	− 3.9	− 0.4	− 0.1	− 0.02
Percentage differences	+ 14	+ 92	+ 9	+ 1	+ 2	+ 11	+ 12	− 5	− 3	− 2	− 1
GRAIN RATION NO. 3. 126 days' feeding on each ration											
Low	2630	446	2311	15.27	5.56	350.6	127.3	88.8	13.5	4.9	1.75
Medium	2979	888	2385	15.50	5.78	369.3	137.9	80.1	12.4	4.6	1.68
Medium ± low	+ 349	+ 442	+ 74	+0.23	+0.22	+18.7	+10.6	− 8.7	− 1.1	− 0.3	− 0.07
Percentage differences	+ 13	+ 99	+ 3	+ 2	+ 4	+ 5	+ 8	− 10	− 8	− 6	− 4
ALL THREE GRAIN RATIONS. 378 days' feeding on low rations vs. 378 days' feeding on medium rations											
Low	8394	1328	7687	14.44	5.04	1090.1	375.2	90.7	13.0	4.5	1.87
Medium	9493	2625	8213	14.61	5.18	1177.9	413.0	85.3	12.3	4.3	1.82
Medium ± low	+1099	+1297	+ 526	+0.17	+0.14	+87.7	+37.8	− 5.4	− 0.7	− 0.2	− 0.05
Per centage differences	+ 13	+ 98	+ 7	+ 1	+ 3	+ 8	+ 10	− 6	− 5	− 4	− 3

LOW AND HIGH GRAIN FEEDING

Rations	Total dry matter eaten	Dry matter eaten in experimental feed	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter in entire ration			Ratio of percent of fat to percent of solids-not-fat
								Milk	Total solids	Fat	

GRAIN RATION NO. 1. 72 days' feeding on each ration

Rations	Total dry matter eaten	Dry matter eaten in experimental feed	Milk	Total solids	Fat	Total solids	Fat	Milk	Total solids	Fat	Ratio of percent of fat to percent of solids-not-fat
	lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	1 :
Low	1645	247	1525	14.28	4.97	216.5	75.2	93.1	13.2	4.6	1.87
High	2047	747	1898	14.18	4.80	265.8	89.4	93.6	13.0	4.4	1.95
High ± low	+ 401	+ 500	+ 373	−0.10	−0.17	+49.3	+14.2	+ 0.5	− 0.2	− 0.2	+ 0.08
Percentage differences	+ 24	+ 202	+ 24	− 1	− 3	+ 23	+ 19	+ 1	− 1	− 4	+ 4

GRAIN RATION NO. 2. 90 days' feeding on each ration

Rations	Total dry matter eaten	Dry matter eaten in experimental feed	Milk	Total solids	Fat	Total solids	Fat	Milk	Total solids	Fat	Ratio of percent of fat to percent of solids-not-fat
Low	1936	324	1690	14.73	5.20	248.3	87.1	85.9	12.7	4.5	1.83
High	2376	879	2000	14.76	5.12	296.5	103.0	83.6	12.4	4.3	1.88
High ± low	+ 440	+ 555	+ 310	+0.03	−0.08	+48.2	+15.9	− 2.3	− 0.3	− 0.2	+ 0.05
Percentage differences	+ 23	+ 171	+ 18	0	− 2	+ 19	+ 18	− 3	− 2	− 4	+ 3

TWO GRAIN RATIONS. 162 days' feeding on low rations vs. 162 days' feeding on high rations

Rations	Total dry matter eaten	Dry matter eaten in experimental feed	Milk	Total solids	Fat	Total solids	Fat	Milk	Total solids	Fat	Ratio of percent of fat to percent of solids-not-fat
Low	3581	571	3515	14.51	5.09	464.8	162.3	89.5	13.0	4.6	1.85
High	4423	1626	3898	14.47	4.96	562.3	192.4	88.6	12.7	4.4	1.92
High ± low	+ 842	+1055	+ 683	−0.04	−0.13	+97.5	+30.1	− 0.9	− 0.3	− 0.2	+ 0.07
Percentage differences	+ 24	+ 185	+ 21	0	− 3	+ 21	+ 19	− 1	− 2	− 4	+ 4

MEDIUM AND HIGH GRAIN FEEDING

Rations	Total dry matter eaten	Dry matter eaten in experimental feed	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter in entire ration			Ratio of percent of fat to percent of solids-not-fat
								Milk	Total solids	Fat	
GRAIN RATION NO. 1. 198 days' feeding on each ration											
	lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	1:
Medium	4867	1335	4560	14.05	4.90	627.0	215 5	93 9	12.9	4.4	1.87
High	5298	1925	5168	14.00	4.75	706.1	235.0	97.8	13.3	4.4	1.95
High ± medium	+ 431	+ 590	+ 608	−0.05	−0.15	+79.1	+19.5	+ 3.9	+ 0.4	0.0	+ 0.08
Percentage differences	+ 9	+ 44	+ 14	0	− 3	+ 13	+ 9	+ 4	+ 3	0	+ 4
GRAIN RATION NO. 2. 180 days' feeding on each ration											
Medium	4588	1241	3960	15.06	5.41	596.9	214.2	85.3	12.9	4.6	1.78
High	4990	1801	4262	14.93	5.24	638.5	224.4	84.7	12.7	4.5	1.85
High ± medium	+ 402	+ 560	+ 302	−0.13	−0.17	+41.6	+10.2	− 0.6	− 0.2	− 0.1	+ 0.07
Percentage differences	+ 9	+ 45	+ 48	− 1	− 3	+ 7	+ 5	− 1	− 2	− 2	+ 4
GRAIN RATION NO. 3. 54 days' feeding on each ration											
Medium	1280	381	1082	15.48	5.77	167.5	62.5	84.6	13.1	4.9	1.68
High	1406	529	1119	15.77	5.95	176.6	66.7	79.8	12.6	4.8	1.65
High ± medium	+ 126	+ 148	+ 37	+0.29	+0.18	+ 9.1	+ 4.2	− 4.8	− 0.5	− 0.1	− 0.03
Percentage differences	+ 10	+ 39	+ 4	+ 2	+ 3	+ 6	+ 7	− 6	− 4	− 2	− 2
ALL THREE RATIONS. 432 days' feeding on medium rations vs. 432 days' feeding on high rations											
Medium	10735	2957	9602	14.86	5.36	1391.4	492.2	87.9	13.0	4.6	1.77
High	11694	4255	10549	14.90	5.31	1521.2	526.1	87.4	12.9	4.6	1.81
High ± medium	+ 959	+1298	+ 947	+0.04	−0.05	+129.8	+33.9	− 0.5	− 0.1	0	+ 0.04
Percentage differences	+ 9	+ 44	+ 10	0	− 1	+ 9	+ 7	− 1	− 1	0	+ 2

Rations	Total dry matter eaten	Dry matter eaten in experimental feed	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter						Ratio of per cent of fat to per cent of solids-not-fat
								In entire ration			In experimental feed			
								Milk	Total solids	Fat	Milk	Total solids	Fat	
BUCKWHEAT MIDDLINGS VS. MIXED FEED NO. 1. 162 days' feeding on each ration														
	lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	1 :
B M	4363	990	3305	14.66	5.23	482.03	171.27	75.9	11.1	4.0	334.7	48.8	17.3	1.80
I	4428	1110	3442	14.50	5.04	495.23	170.52	77.6	11.2	3.9	309.7	44.6	15.4	1.88
I ± B M	+65	+120	+137	−0.14	−0.19	+13.20	−0.75	+1.7	+0.1	−0.1	−25.0	−4.2	−1.9	+0.08
Percentage differences	+1	+12	+4	−1	−4	+3	0	+2	+1	−2	−7	−9	−11	+4
BUCKWHEAT MIDDLINGS VS. MIXED FEED NO. 4. 162 days' feeding on each ration														
B M	3583	879	2455	15.57	5.77	380.59	140.70	68.9	10.7	3.9	284.9	44.5	16.6	1.70
IV	3752	1010	2377	15.49	5.61	366.79	131.97	63.7	9.8	3.5	236.9	36.7	13.3	1.76
IV ± B M	+169	+131	− 78	−0.08	−0.16	−13.80	−8.73	−5.2	−0 9	−0.4	−48.0	−7.8	−3.3	+0.06
Percentage differences	+5	+15	−3	−1	−3	−4	−6	−8	−9	−10	−17	−18	−20	+4
QUAKER DAIRY FEED VS. MIXED FEED NO. 1. 342 days' feeding on each ration														
Q D F	7848	2425	4700	15.86	6.04	737.26	277.25	59.4	9.3	3.5	194.1	30.5	11.5	1.63
I	7800	2362	4982	15.88	6.03	781.71	293.31	63.4	10.0	3.7	210.5	33.0	12.4	1.63
I ± Q D F	−48	−63	+282	+0.02	−0.01	+44 45	+16.c6	+4.0	+0.7	+0.2	+16.4	+2.5	+0.9	0
Percentage differences	−1	−3	+6	0	0	+6	+6	+7	+8	+6	+8	+8	+8	0
QUAKER DAIRY FEED VS. MIXED FEED NO. 4. 216 days' feeding on each ration														
Q D F	5348	1448	3381	15.42	5.72	513.21	187.20	63.6	9.7	3.5	234.7	35.7	13.0	1.70
IV	5420	1506	3377	15.45	5.73	514.86	188.06	62.7	9.5	3.5	224.4	34.2	12.5	1.70
IV ± Q D F	+72	+58	−4	+0.03	+0.01	+ 1.65	+ 0.86	−0.9	−0.2	0	−10.3	−1.5	−0.5	0
Percentage differences	+1	+4	0	0	0	0	0	−1	−2	0	−4	−4	−4	0

Manner of treatment	Total dry matter eaten	Dry matter eaten in experimental feed	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter						Ratio of per cent of fat to pe cent of solids-not-fat
								In entire ration			In experimental feed			
								Milk	Total solids	Fat	Milk	Total solids	Fat	
GROOMING VS. NO GROOMING. 126 days' feeding each way														
	lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	1 :
Grooming	3118	867	2743	14.36	4.97	393.97	136.37	88.0	12.6	4.4	316.9	45.5	15.8	1.89
No grooming	3156	881	2850	14.48	5.01	412.66	142.69	90.7	13.2	4.6	324.2	47.0	16.2	1.89
No gr. ± gr.	+38	+14	+107	+0.12	+0.04	+18.69	+ 6.32	+2.3	+0.6	+0.2	+7.3	+1.5	+0.4	0
Percentage differences	+1	+2	+4	+1	+1	+5	+5	+3	+5	+5	+2	+3	+3	0
WATER AT WILL AND AT INTERVALS. 90 days' feeding each way														
Will	2288	629	2615	14 24	4.92	372.61	128.74	114.8	16.3	5.7	436 2	59.4	20.5	1.89
Intervals	2280	628	2615	14.40	5.04	374.55	131.50	114.7	16.5	5.9	416.0	59.8	21.0	1.86
Intervals ± will	−8	−1	0	+0.16	+0.12	+ 1.94	+ 2.76	−0.1	+0.2	+0.2	−20.2	+0.4	+0.5	−0.03
Percentage differences	0	0	0	+1	+2	+1	+2	0	+1	+3	0	+1	+2	−2
WARMED WATER AND COLD WATER. 360 days' feeding each way														
Warmed	9114	2489	5303	14.34	4.83	763.39	257.80	58.3	8.4	2.8	213.1	30.7	10.4	1.97
Cold	9145	2483	5425	14.29	4.83	777.15	262.92	59.3	8.5	2.9	218.3	31.3	10.6	1.96
Cold ± warmed	+31	−6	+122	−0 05	0	+13.76	+ 5 12	+1.0	+0.1	+0.1	+5.2	+0.6	+0.2	−0.01
Percentage differences	0	0	+2	0	0	+2	+2	+2	+1	+4	+2	+2	+2	−1

NOTE EXPLANATORY OF VI "DIFFERENCE TABLES," (PAGES 493-494), AND VII "RESULTS OF EXPERIMENTAL FEEDING," (PAGES 495-499)

Although "difference tables" have been printed in the last four reports accompanied by full explanations of their meaning, they are so condensed from the data of table V that explanatory notes seem still in order.

When a cow eats a certain ration during a feeding period, another during a second period, returning to the first ration for a third period, all three being of equal lengths, and, as far as may be, all other things being equal, it is fair to assume, and in the discussion of feeding experiments is usually assumed, that the average of the results obtained during the first and third periods on the ration then fed is what would have been secured during the second period had the feeding continued on one ration. A comparison of this average with the results actually obtained with another ration serves to show the relative value of the different fodders and feeds. The *difference between these calculated averages and the actual results* form the "differences" which measure the relative values of the two rations.

The first comparison of the record of the cow Ceres (page 483) is given in full to show more clearly just what is meant by the figures in the "difference tables."

Record of CERES for the experimental portions of periods I, III and II (See page 483)	Total dry matter eaten	Dry matter eaten in experimental feed	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs of dry matter					
								In entire ration			In experimental feed		
								Milk	Total solids	Fat	Milk	Total solids	Fat
	lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
Average of actual records for period I and III (mixed feed No. 1)	475.9	124.9	469.2	14.92	5.51	70.06	25.84	98.6	14.8	5.5	375.9	56.2	20.7
Actual record for period 2 (mixed feed No 1 + palm oil	471.2	130.4	499.5	15.08	5.86	75.34	29.25	106.0	16.0	6.2	383.1	57.8	22.4
Record made upon mixed feed No. 1 + palm oil ± the average of those made on mixed feed No. 1	−4.7	+ 5.5	+30.3	+0.16	+0.35	+5.28	+3.41	+7.4	+1.2	+0.7	+ 7.2	+1.6	+1.7

The first horizontal line of figures shows the average of the records of dry matter eaten, of milk, solids, and fat given, etc., obtained during the experimental portions of the first and third feeding periods, while the cow was eating the cottonseed-linseed (mixed feed No. 1) ration, (page 483). The second horizontal line of figures shows the actual records of dry matter, milk, etc., obtained during the experimental portion of the second period, while the palm oil was added to her otherwise unchanged ration (fourth line page 483). The third horizontal line shows the amounts, greater or less as the case may be, of dry matter eaten, milk given, etc., when the palm oil was fed as compared with the average of the records on the cottonseed-linseed (mixed feed No. 1) ration. These differences furnish a measure of the relative value of the two rations, it being assumed, as stated above, that the averages correctly indicate the consumption and production which would have occurred during the intervening period had the ration remained unchanged.

The figures in the third horizontal line in the above table, together with eight other sets similarly obtained by comparing Cowslip's average of periods V and VII with VI, Haidee's V and VII with VI, Ladysmith's III and V with IV, Naomi's III and V with IV, Pauline's III and V with IV, Pretoria's I and III with II, Priscilla's V and VII with VI, and Ruth's I and III with II added, each column by itself, give the tenth horizontal line in table (*a*) "totals of differences," (page 493) beginning 9—77.4 +4.1 +51.5, etc. The figures in table (*b*) "percentage differences"—which are the final results and measures of the relative worth of the various rations—are obtained by dividing the "total differences" by the total actual consumption (of dry matter) or production (of milk, solids, fat and the same proportionate to 100 pounds of dry matter eaten). Thus for example, the calculated amounts of dry matter eaten when the mixed feed No. 1 was fed to the cows mentioned above in the averages of the experimental portions of the periods given in couplets—for example, Ceres' I and III, Cowslip's V and VII—was 3860.5 pounds. This is 77.4 pounds more than the amounts actually eaten when the palm oil was fed; $77.4 \div 3860.5 \times 100 = 2.00$. Hence we say that the "percentage difference" is -2, or in other words, that the cows fed on the mixed feed ration ate 2 per cent more dry matter than would have been the case had they eaten the ration to which palm oil had been added at precisely the same time they did eat the mixed feed. This figure (-2) leads the tenth horizontal line in table (*b*) "percentage differences." (page 494.) Similar comparisons with the remaining items show the per cent of excess of consumption or product resulting from the use of mixed feed No. 1 as compared with the same when mixed with oil.

The outcome of certain of the experiments is also shown in a somewhat different manner in table VII "Results of Experimental Feeding on Different Rations," wherein the total products for each period and for each calculated period are added. Thus, for example, in the case of the two cows Idarella and Suenette each fed six periods, including 12 eighteen-day experimental portions, a comparison of 162 days feeding for one cow on each ration may be made and neither side of the comparison suffer from the effects of advancing lactation, this being equalized. The use of the data found in table V "Production Records," with the cows in question for the experimental portion of the periods stated below will give the equivalent of 162 days' feeding on a buckwheat middlings ration.

Idarella, periods III and V	36 days feeding
Suenette, periods II, IV and VI	54 " "
Idarella; the average of records of periods I and III and of III and V on the buckwheat ration; equivalent respectively to what might reasonably have been expected to have been the results in periods II and IV had the feeding on buckwheat middlings been continued	36 " "
Suenette; the average of records of periods II and IV and IV and VI on the buckwheat ration; equivalent, etc., to periods III and V on buckwheat feed	36 " "
	Equivalent to 162 days feeding

Using the data on the mixed feed No. 1 ration the following combination gives 162 days feeding:

Idarella, periods II and IV	36 days feeding
Sue, periods III and V	36 " "
Idarella, the average of records of periods II and IV, and of IV and VI on the mixed feed ration; equivalent, etc. to period III and V on mixed feed	36 " "
Suenette, the average of records of periods I and III, of III and V and of V and VII on the mixed feed ration; equivalent, etc. to periods II, IV and VI on mixed feed	54 " "
	Equivalent to 162 days feeding

This permits the calculation of the consumption and production of each cow on each ration for the selfsame days of the experimental portion of the periods other than the first and last used with each cow, thus affording an excellent and accurate measure of the relative worth of the two rations. The result of this comparison is given in table VII (upper third of page 498) in the first set, the buckwheat figures beginning 4363, 990, 3305, and the mixed feed data, 4428, 1110, 3442. The average percentages of total solids and fat are obtained by addition and not by cross division. This gives to each cow the same influence upon the final results instead of giving greatest preponderance to those yielding most largely of milk, solids and fat, and less to those giving smaller amounts.

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